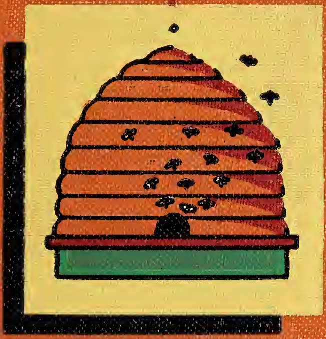
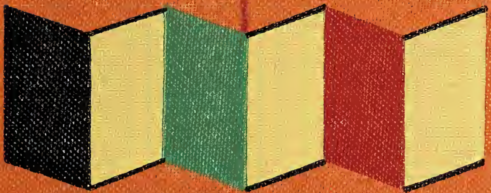
# EXPLORING SCIENCE
# Five
THURBER





*Teachers' Edition*

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# Teachers' Manual for
# EXPLORING SCIENCE
## Five

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# Contents

**Introduction** 5

*Putting Science in the Curriculum* 5
*How to Use the Books* 8
*Special Techniques for Teaching Science* 12
*Conservation Education* 16
*Health and Safety Education* 17

**Detailed Teaching Suggestions for Book Five** 19

*Science Definitions* 21
Insects That Work Together 26
Controlling Fires 33
Streams at Work 43
Sugar and Starch 53
Warm Weather Indoors 63
Animal Tracks and Signs 71
The Winter Sky 81
Electric Circuits 90
Rainbow Colours 101
Plants and Light 109
Lifting Things 119
Boats 127
Flowers and Their Work 135
Life in Quiet Water 143

**List of Science Materials** 153

**General References for the Teacher** 157

# Introduction

## PUTTING SCIENCE IN THE CURRICULUM

"Learn through doing!" "Study things—not ideas!" What excellent precepts for a science programme! For children love to "do" more than they care to sit passively. And they learn best when they are using their senses to study the world about them.

Imagine a cheerful classroom with children taking care of radish seedlings and goldfish; with children keeping records of tadpole growth and weather changes; with children making model boats and cricket cages; with children comparing what books say about robins with their own observations; with children experimenting, arguing about results, and suggesting new ways to prove that there is water in the air.

This is a picture of a science programme that is meant for children. These children are learning more than isolated facts; they are learning to work together, to solve problems, to handle tools, to use books. And they love every moment of it!

Teaching like this is fun. The outcomes are highly satisfying. Children need only the ideas for things to do, a little help in finding materials, and some encouragement. They supply the necessary enthusiasm and energy.

### Some Reasons for Elementary Science

The elementary school is concerned with the growth of the child, —his intellectual, social, emotional, and physical growth. All subject-matter areas have the same general objectives, but they use different methods and content for attaining them. Science, because it deals so much with tangible things, makes several unique contributions.

Much of the programme of the Exploring Science Series involves manipulation, thus developing muscular co-ordination, skill with tools, and familiarity with materials. A number of otherwise outstanding pupils are seriously deficient in manipulative ability, this phase of their education having been neglected. They benefit greatly from opportunities to work with the "things" of the science programme. In contrast, there are a number of retarded readers who find in this phase of science their only opportunities to equal or excel their classmates.

A rich variety of science projects gives all children opportunities for self-expression. Some children best express themselves by making models; some through making friezes, charts, and posters; some by writing science stories, keeping notebooks, and producing science plays; some through collecting and exhibiting.

Science activities encourage pupils to plan, to use ingenuity, and to exercise initiative. When the activities are carried out by small groups, the pupils learn to plan and work together, to share responsibilities, and to assume leadership.

Experiments, field trips, projects, and similar activities stimulate pupils to turn to books for information. By comparing what authorities say with their own observations, the pupils tend to become more critical and they develop habits of open-mindedness and delayed judgment.

Certain phases of the subject matter of science have immediate and important values. Especially important are the learnings that contribute to establishing better health and safety practices. A large share of health and safety education is based upon scientific information. Another area that benefits from science subject matter is conservation education; so closely is conservation allied with science that the two are usually included in the same programme. (Pages 16–18 of this Teachers' Edition discuss the role of science in conservation and health and safety education.)

### How Much Time for Science?

"Can you afford fifteen minutes three times a week for science?" This in answer to teachers who are concerned about the already crowded class curriculum. Sucessful science programmes have been carried out with as little time as this scheduled for science class work. More time is to be desired, but there need be no sacrifice of other important areas when science is added to the school programme.

An elementary science programme does not demand a great deal of formal class time to keep it progressing satisfactorily. Three or four short periods weekly, or the equivalent, are adequate for pupil motivation, with much of the actual science work being carried on outside class time. Most of the units in the Exploring Science Series require two or three weeks for satisfactory development—for planning, experimenting, and discussing.

Science does not require much class time because children make time for science. They find the work too exciting to be dropped between lessons. They rush to school in the morning to see how their plants and animals have fared through the night. They use much of their free time during the school day for science activities. If permitted they will stay after school to work with science materials. And it is not unusual for a majority of the pupils to repeat at home the experiments they have carried out during their science lessons.

It is possible to make science the core of the entire school programme; many children prefer to make science just that. Many children prefer to talk and write about science for their language work; many prefer to read about science during reading periods; some prefer to base their art work on science subjects. As one teacher put it, "I have learned how to start a science programme. Now show me how to stop it!"

### Planned and Incidental Science

A planned programme ensures steady progress from grade to grade with a minimum of overlapping and repetition. A planned programme ensures breadth of content and a balance among the various subject-matter areas of science.

A planned programme gives point and direction to the work of the pupils and keeps their enthusiasm high. It opens up new avenues for exploration. Without planning, science programmes usually become haphazard and are sometimes neglected.

On the other hand, there should be time available for what is called "incidental" science. Pupils should have an opportunity to watch a butterfly that has just emerged or to study a rainbow that has just appeared in the sky. Incidental science deals with the unexpected; it is often responsible for some of the most worth-while outcomes of the science programme.

### Equipment for the Science Programme

Mayonnaise jars, tin cans, paper clips, and soda straws—such are the materials needed for a science programme. There is nothing mysterious about these commonplace materials. When a child does an experiment with a mayonnaise jar he is working with something familiar to him. He can repeat the experiment at home if he wishes. To him, science is the study of familiar things.

A list of materials needed for each unit of the Exploring Science Series is included in the specific suggestions for teaching each unit. A list of all the science materials needed for the year's programme is included at the end of this Teachers' Edition. Children can supply most of the items, such as tin cans and glass jars. Some of these should be stocked in quantities so that there is always a supply on hand.

It is well to make a list of materials that children cannot bring in. This list may include such raw materials as soft pine lumber, wire, nails, and screws. The list should then be discussed with the principal or the supervisor for items that can be supplied by special departments of the symbol system. Usually only a few items need be purchased separately.

Ideally, materials for an activity programme should be provided in quantity. Instead of a single hand lens, a class of thirty children should have at least fifteen hand lenses. Although this may seem prohibitively expensive it need not be so. Other teachers in the school will probably be able to use the same materials. By providing a central storage space, and by working out a schedule for the use of the materials, the per-pupil cost becomes insignificant.

## HOW TO USE THE BOOKS

Each pair of facing pages in the books of the Exploring Science Series sets the stage for an exciting adventure in science—an experiment, a demonstration, a field trip, a class project. The books are study guides rather than science readers. They present a programme to the pupils and show them how to carry it out.

Some teachers may choose to follow the books page by page, deviating little from the programme as it is presented. Their classes will be meaningful and fun for the pupils.

Other teachers will prefer to modify the programme to fit their special needs. Each book has been planned to permit a high degree of flexibility. How to take advantage of this flexibility and other features are discussed below.

### How the Books Are Organized

Science experiences form the basis for the Exploring Science Series. Emphasis is upon first-hand experience activities supplemented by information given through pictures and reading.

The activities have been selected to provide experiences in all the common areas of science, both physical and biological. This presents a well-rounded programme that appeals to different interests and gives a broad background in science.

The activities are grouped in units centred about such familiar subjects as “Mirrors” and “Sunshine” rather than in units of formalized science. A single unit can, and often does, cut across several conventional subject-matter areas.

The material of a unit is developed in two-page blocks, each of which usually takes up a separate topic. This is a successful pattern often found in how-to-do-it books. It is useful in these science books because pupils can carry out an activity without turning pages.

### The Teachers' Editions

The special Teachers' Editions for the Exploring Science Series contain the material given in the pupils' editions together with detailed suggestions for using this material.

Each unit is introduced with a discussion of the possible outcomes of the unit and a description of the part the unit plays in the entire science programme. Necessary materials are listed. Different methods of developing and enriching the unit are suggested, and valuable background information is provided.

Following these general helps, the material in the unit is considered page by page. Different methods of developing lessons are suggested. There is advice about the use of tools and materials. Possible difficulties are anticipated, and there are many helpful identifications of unlabelled pictures in the text. Answers to questions pupils might ask, follow-up activities, and references are listed. See PREPARING FOR THE UNIT for the best time to begin a unit.

The Teachers' Editions give teachers confidence in their ability to teach science. The Teachers' Editions help teachers to take full advantage of the special features of the books, thus providing a rich and challenging programme.

### Scheduling Science

Most of the units in the Exploring Science Series require two or three weeks for satisfactory development. Children should not be hurried through a science programme. They need time to experiment, to discuss results, to try experiments again. They need time between lessons, too. A pupil who has connected a dry cell to an electric lamp during a science lesson will want to repeat the experience during his free time. He may also wish to repeat the experience at home.

Most of the two-page blocks of a unit serve as the subject for one or more lessons each. One of these blocks may describe an activity that requires a full lesson for completion. Some of the activities may be started in one lesson, as with many experiments with plants, and then finished during a lesson at a later time. Field trips require additional lessons for preparation and for follow-up. Projects usually require several lesson periods.

It is recommended that the minimum time allotment for science be scheduled as lesson periods. Additional time can be used for incidental science or for extending scheduled lesson periods as needed.

There are several ways to provide additional science time without scheduling it at the expense of other subjects. If there is a "science table" at the side of the room, materials may be placed on it for pupils to use in their free time, both in and out of school hours. Individual projects can be started in school and completed at home. There can be correlation with reading, language, art, and social studies. As long as the science programme is interesting, the pupils will find time for it.

### Modifying the Basic Programme

Perhaps spring comes early to your section of the country. Perhaps your community makes much of Fire Prevention Week. The teaching calendar should recognize these and other important events. The flexibility of the Exploring Science Series makes it possible to shift units as desired because the units within a book are independent of each other. A unit involving fire can be moved to early fall, and a unit involving spring can be scheduled for the time when daffodils burst from the ground.

Likewise the material within a unit may be re-organized to take advantage of special conditions. Re-arrangement of the two-page blocks may permit a more suitable activity to open a unit. Additional activities can be inserted as desired. One may also delete some of the activities that do not seem appropriate to the teaching situation.

The class may wish to take up science material that is not included in the programme of the books. This is admirable and the class should be given every encouragement. There are a few cautions that should be observed. The teacher should be sure that the subject is of interest to all pupils and not to just a few of the more aggressive individuals. She should be sure that there are suitable activities to be used in teaching the proposed subject. She should try not to take up material that will be taught by teachers in later grades. If pupils suggest a topic that does not seem suitable for the entire class, the topic may be assigned to certain interested pupils as optional work. Assigning a particular topic to a superior child will frequently re-awaken his interest by confronting him with a real challenge to his ability.

### Beginning a Unit

To start children thinking about magnets put magnets in their hands. To start them thinking about frogs put a frog where they can watch it. That is all there is to starting a new unit.

New materials may be presented in several ways. Sometimes, as with magnets, the materials may be put in the hands of the pupils with little explanation. Sometimes an interesting demonstration can be used; for example, a "race" with burning candles under various-sized jars to see which candle goes out first. Living things, particularly things that move, need only be placed where pupils can watch them.

Special days and special events offer possibilities for introducing new topics. A St. Patrick's Day carnation raises questions that lead to experiments with water movement in plants. Coloured Easter eggs raise questions about dyes that lead to experiments with dyeing cloth.

First-hand experiences make the most interesting and the most challenging approaches to new units. There can be no one best approach to a unit because conditions vary so much, but a little imagination adapts most activities to meet the situation.

### Developing a Unit

The pattern in which the material is presented in the Exploring Science Series is one that has been used successfully, but it is not necessarily the most satisfactory for a particular situation. There can be no one best pattern: much depends upon the interests of the pupils, upon the teaching situation, and upon unpredictable events. A teacher should feel free to modify any unit—re-arranging the topics, adding material, and deleting material.

It is important that there be variety in a unit. Variety keeps interest high and provides for individual differences. Use experiments, field trips, demonstrations, model-making; and science play-writing, to obtain the necessary variety.

Different types of activities make different contributions to a science programme. Experiments and field trips provide the basic first-hand information. Study of books and pictures supplements first-hand information with information that has been gained by other people in different situations. Model-making, play-writing, and similar activities serve to organize information.

These books make use of many different types of activities in the development of the programme. The detailed sections of these Teachers' Editions suggest still more types of activities that can be used to enrich the programme.

### Evaluating Outcomes

As yet, no one has discovered how to measure the truly important outcomes of a science programme. Certainly the facts of science as tested by pencil-and-paper tests are of small consequence. The important outcomes are the attitudes that pupils develop, the skills they gain, and the habits they acquire.

Evaluation of the effectiveness of a science programme is chiefly one of personal judgment. One must depend upon many small but significant signs. One may look for signs of general interest. How many pupils participated in each activity? How many children volunteered for optional activities? How many pupils brought in materials when asked to do so? How many brought in materials without being asked? How many pupils repeated science activities at home? Did pupils talk about their science experiences outside school?

Specific achievements can be used as a measure of success. What experiments were carried out? What field trips were taken? What projects were completed? What books were read?

One may look for signs of pupil growth. How many normally quiet children took active parts in class work? How many passive children took on leadership responsibilities? How many "slow" readers turned to books for information? How many pupils turned out work of improved calibre?

To measure the progress of individuals look for interest, effort, growth, and achievement. Not all children can be judged by the same standards, but if in his own way a pupil has shown evidence of each of the above, one may feel satisfaction with the results.

## SPECIAL TECHNIQUES FOR TEACHING SCIENCE

Most of the teaching techniques used in other subject-matter fields apply equally well to science teaching. But when pupils begin to experiment, to perform demonstrations, to take field trips, and to build models, it is obvious that a teacher must have a knowledge of some additional teaching techniques.

The majority of the activities suggested in the Exploring Science Series are direct experience activities. They are simple and they are clearly described in the textbooks. A teacher should have little difficulty in helping pupils carry them ont, but if difficulties do arise, the detailed assistance given in the Teachers' Editions should quickly clear them up. The real problem that faces a teacher is not that of giving technical assistance with activities: the problem is finding ways to help pupils to gain the most from the experiences.

Science education stresses a number of major goals such as the development of critical thinking and the habit of withholding judgment. The activities which pupils carry out set up the situations that permit these goals to be attained. It is in working toward these major outcomes that many elementary teachers need help.

### The Problem-Solving Approach

What a child learns may be of less value to him than the way he learns it. A curious child can be led to speculate, to experiment, to check conclusions. He can be given practice in defining problems.

He can be given opportunities to exercise his ingenuity. He can be encouraged to develop a critical attitude and an open mind. Such experiences are worth more to him than the bits of information he may pick up.

Elementary science is well-adapted to the problem-solving approach. The materials of science awaken curiosity: "How did this dandelion get in my garden?" "How can I connect this dry cell to an electric bell?" "Why does my dog prick up his ears when he wants to hear better?"

It must be remembered, however, that questions do not automatically become problems. A teacher may ask, "How do the people of Canada get their drinking water?" only to discover that few children care. Children are more interested in small and immediate problems: "How can fish stay under water?" Teachers should always re-examine the problems they intend to use to be sure that they have problems which challenge the pupils.

### Answering Questions

It is a matter of courtesy to recognize all questions that pupils raise, whether the questions seem relevant or irrelevant, intelligent or silly. Perhaps if we could know all that goes on in a child's mind we would consider all his questions more seriously.

Recognition of a question does not mean that the question must have an immediate answer. Teachers probably answer too many questions for the good of the child. When a teacher answers a question, or selects one of the pupils' guesses as correct, there is nothing more for the pupil to do. It is better to encourage him to speculate, experiment, observe closely, and turn to recognized authorities for information to answer his own questions.

The more a teacher knows of a subject the easier it is to avoid the direct answer in favour of suggestions for finding answers independently. But when a teacher's background in a field is limited, it is still possible to make suggestions that send a pupil to experiments and to books for information—and for the answers.

A teacher must often say, "I don't know, but . . ." and follow up with suggestions for planning an experiment, or with the name of a recognized authority. There are innumerable questions that neither the teacher nor anyone else can answer. Physicists do not know why a magnet picks up iron. Biologists do not know why a bobolink migrates to South America in autumn. No one knows why the earth pulls things toward it or how a green plant produces sugar. The teacher must never be afraid to say, "I don't know." These are the words that challenge mankind. Perhaps that teacher's pupils will be the very ones to solve these age-old questions.

### Experiments

Children love to experiment—to find out by "doing," as compared with learning through reading and being told. This is because children like to manipulate, they like to see things happen, there is an element of suspense involved, and perhaps they subconsciously recognize the validity of information gained this way.

Experiments in the elementary school should be informal. Problems are best stated in the words of the children. There is no place for the formalized pattern of "objective, apparatus, procedure, observations, and conclusions."

The best problems for experiments are the small problems that can be solved with simple equipment and in a short time. "Can a magnet attract a paper clip through cloth?" "Will grass turn yellow when a board is laid on it?" "Will cocoa pass through a filter?"

A number of worth-while problems arise from discussions that pupils hear at home. "Does hot water freeze faster than cold?" "Will aspirin tablets keep cut flowers from wilting?" "Is the coldest place in a room near the floor?"

Certain problems are too broad for children to solve. "Do plants need light in order to live?" "Does a fire need air in order to burn?" It would be improper to let pupils feel that they had answered such questions after two or three experiments. Instead of such problems, pupils should be encouraged to work on more limited problems. "Do bean seeds need light in order to start growing?" "Will a candle burn longer in a quart jar than in a pint jar?"

While pupils are carrying out an experiment, the teacher should refrain from influencing their conclusions. Only after the pupils begin to discuss their results should the teacher begin to raise questions that will encourage them to modify their conclusions. Perhaps the pupils have discovered that a pot of corn seedlings in a dark closet died after six days. Some of the pupils have decided that corn seedlings need light in order to live. The teacher may now suggest that the seedlings might have died anyway, perhaps because the soil was poor. She may then encourage the pupils to set up the experiment with another pot of seedlings in a light place.

Teachers are sometimes upset because an experiment does not "work." Actually, all experiments "work" in that they show that something happens or fails to happen. When an experiment does not turn out as anticipated, it is because some unconsidered factor has entered or because the expected result is wrong. But that is the fun of experimenting, not knowing what the results are going to be and trying to account for what does happen.

### Field Work

The Exploring Science Series encourages field work as one of the most effective methods of learning science. Few are the units that do not suggest directly or indirectly some type of field work.

Possibilities for field work are almost endless. School buildings often have heating systems, gymnasiums, shops, kitchens, medical centres, and fire protection devices. School yards frequently have play equipment, flagpoles, shaded and unshaded areas, and varying kinds of vegetation.

Near schools there are often parks, gardens, vacant lots, and fields where plants can be studied. Where there are plants there are insects and other animals. Near schools there are sometimes automobile service stations, stores, greenhouses, and other business establishments. These present many opportunities for the study of science.

Field work should be planned carefully. Children should know what they are to look for. Do crocus blooms stay closed on cloudy mornings? How is air put in a tire? These are simple, direct problems well fitted for field investigations.

Outdoor experiments make good subjects for field work. The pupils may compare the temperatures of pans of water in sunshine and in shade. They may study the effect of sprinkling water on a pile of soil.

Field work is usually more effective when each pupil has something to do with his hands. The children may collect coloured leaves. They may take the temperatures of the soil in different places. They may write the answers to questions formulated before the trip.

Techniques for handling pupils in the field are somewhat different from handling pupils in the classroom. Each pupil must have something to do and he must know exactly how to do it. One of the important differences between indoor and outdoor situations concerns the amount of talking by the teacher. Lecturing and class discussion usually fail in the field because there are so many distracting elements. These techniques should be reserved for the preparatory and follow-up lessons. Once in the field, the teacher should generally talk only with individual pupils who come up with special questions.

### Science Projects

Science projects exist in such rich variety that it is possible to appeal to the many interests and talents in a class. Children who like to work with tools enjoy making models. Children who like to draw and paint enjoy making posters, charts, and friezes. Children who like to write find opportunities to write stories and plays. Children who like to collect will enjoy preparing exhibits of their science collections.

Science projects such as these encourage pupils to plan, to use ingenuity, to persist at a job until it is done. Group projects give children opportunities to work together, to share, to assume leadership. The final products are tangible evidence of accomplishment and give the children deep satisfaction.

Such projects are important in the learning process. They bring together information and organize it in easily understood patterns. Often the projects give rise to new problems for the pupils to work on.

Completed projects should be put on exhibition whenever possible. Projects may be displayed in the foyer of the school, at Parents' Nights, and at P.T.A. meetings. They may be exhibited in store windows during Education Week. Local newspapers are usually delighted to publish photographs of exhibits and the children who made them; the teacher need only call up the editor and notify him of the displays. Through projects of this kind, parents gain a better understanding of what goes on in the school programme, and children enjoy sharing their science experiences with them.

## CONSERVATION EDUCATION

Elementary science should make significant contributions to conservation education. Science deals with plants and animals, rocks, soil and water, and with the scientific principles that control these natural features. Science helps to meet the three general objectives of conservation education—1) to give information about natural resources, 2) to develop desirable attitudes towards the use of natural resources, and 3) to give experiences with conservation practices.

Studies of the life histories of living things give an understanding of their problems. Each book of the Exploring Science Series includes a number of life history studies, and others are suggested in the Teachers' Editions.

Interrelationships among plants, animals, and their natural environments are also important. Better understanding of interrelationships would have prevented the admission of many animal and plant pests into this country, the extinction or near extinction of many species, and the many other mistakes we have made in handling our environment. This Series stresses interrelationships in all units dealing with the natural environment.

In general, when pupils gain sufficient backgrounds of information they develop proper attitudes. Having seen a badly eroded pasture, having learned the value of topsoil and the difficulty of replacing it, they recognize the waste and the need for conservation practice. They need no indoctrination; they draw their own conclusions from the facts.

These books also show children how to practise conservation for themselves. They are encouraged to take care of their clothing and their toys. They learn to conserve heat by closing doors and windows in cold weather. They are instructed in the prevention of grass fires and forest fires. They learn how to co-operate in fire prevention about the home.

Children are also encouraged to help keep streets, roadsides, parks, and picnic grounds free from litter. Much education is needed in the proper use of one of our great resources, the beauty of the countryside. By taking pupils to places that are beautiful and then for contrast to places that have been abused, the teacher gives them training in an important area of conservation education.

## HEALTH AND SAFETY EDUCATION

All areas of the elementary school curriculum must share in the responsibility for helping children to learn to take care of themselves. Science is especially important since it contributes much of the informational background necessary. By broadening its goals, the teacher may use science as the basis for the health and safety programme when classroom time does not allow for two separate programmes.

These are the areas commonly included in health and safety programmes for the elementary school:

The meaning of health
Body growth and development
Nutrition
Circulation and respiration
Digestion
Elimination
Bones (including teeth) and muscles
Skin, hair, and nails
The senses
Ears, nose, and throat
Rest and relaxation
Mental health
Sanitation

Communicable diseases and their prevention
Tobacco, alcohol, and drugs
Preventing falls
Safety with tools
Preventing fires
Traffic safety
Treatment of small wounds
Prevention of sunburn
Water safety
Safety with animals
Safety with electricity (including lightning)

The Exploring Science Series provides a combined science and health programme when such a combination is desired. Most of the units in each book contain health and safety material. For instance, the fourth grade unit "Static Electricity" includes a lesson on safety during a thunderstorm. The sixth grade unit "Water in the Ground" includes several lessons on safe drinking water. In addition, each book contains one or more units dealing primarily with health and safety, which are noted at the end of each book under "The Major Topics Presented in Each Unit." Thus a complete integration of the two programmes can be carried out in a completely natural way.

The flexible organization of the books permits the emphasis to vary according to need. If the school provides a separate health and safety programme, only a minimum amount of time need be spent on repetitious material in this Series. But if the combined programme is in operation, the health and safety material may be expanded as desired. The special helps in the Teachers' Editions show how to make the most of situations that arise from working with the Exploring Science Series.

It should be remembered that the science programme cannot assume the complete responsibility for health and safety education. Health and safety instruction must go on at all times. Children need orientation in the use of drinking fountains, public toilets, and school washrooms. They must be reminded constantly about washing after playing with things that dirty their hands, after going to the toilet, and before eating. They must be encouraged to play actively and then rest quietly. Safety in the classroom and on the playground must be stressed constantly. And the whole problem of mental health —good social adjustment, self-confidence, self-reliance—should be an every-minute-of-the-day concern of the teacher.

# Detailed Teaching Suggestions for Book Five

As a class advances from grade to grade through the science programme, the spread of individual differences continues to widen at an ever-increasing rate. This is certainly due in part to the increasing diversity of experiences that pupils have outside of school. It is due in part to the discovery and development of special talents of individual pupils. And it may be due in part to actual regressions as pupils become discouraged or develop antagonisms for certain aspects of school work.

By the time pupils have reached the intermediate grades, individual differences profoundly influence the nature and conduct of the science programme. Certain pupils have become deeply interested in such topics as birds and wild flowers; others seem to care for little except astronomy, airplanes, or chemistry. A small number of children read avidly any science books written for this level; a few others refuse to be interested in any kind of reading material. Some children have developed a love for painting, some for model-making, some for collecting. And all too many are beginning to avoid the use of hammers, saws, and similar tools. Several, usually among the girls, have developed strong aversions to snakes, fishworms, and insects.

Individual differences present a twofold problem to the fifth-grade teacher. She must make the best use of all these diversified interests and abilities, encouraging each pupil to grow to the utmost along his specialized line. She must also try to broaden the individual child, encouraging the reluctant readers to read, the mechanically inept to use tools, and the prejudiced little girls to look at snakes more dispassionately.

The common denominator of interest in the fifth grade is the direct learning experience, such as the experiment, the demonstration, and the field trip. One may introduce a new topic with first-hand experiences, assured that interest will be high and general among the class. Thus is given the common core of learning from which pupils may diverge in the directions that benefit each the most.

The separate units of *Exploring Science Five* are each based upon a number of direct-learning experiences. Discussions, reading, and telling are kept in a supplementary role. The specific suggestions that follow in this Teachers' Edition show how to begin with each common core of experiences and develop the various topics in several ways.

Fifth-grade pupils benefit most from simple, direct types of activities. Many children are confused by activities that involve abstract ideas and several steps of reasoning. On the other hand, it is a mistake to insist upon activities that are so simple the pupils know the outcomes. Each activity should present something new and challenging to look for.

The development of critical thinking is an important outcome of a science programme. One should never underestimate the ability of children to think clearly. Fifth-grade pupils are naturally more cautious in making statements than most adults realize. Too often it is the teacher herself who muddles their thinking by hurrying them into unjustified statements.

Pupils should not be asked to draw conclusions from a single observation. They should be encouraged to test results again and again, never feeling satisfied with a statement that is too broad for the data they have collected. A teacher can and should help them in this by being herself sceptical and demanding of proof. Although this takes time, it must be remembered that the development of sound habits of thinking needs time and, as an outcome, is worth infinitely more than the accumulation of a number of hastily acquired bits of information.

Verbalization is always of secondary importance in a science programme. It is vastly more important for pupils to have had an experience than to be able to talk about it. None the less, fifth-grade pupils should be developing a certain amount of verbal ability. Teachers will find that they can take advantage of the strong interests in science to help children to learn to express themselves more clearly.

Fortunately, the common phenomena of science can be described and explained with common words. No highly specialized vocabulary is needed. Pupils can talk about food-making in green plants and the upward push of water without using such terms as "photosynthesis" and "buoyancy." There will be pupils who are ready, through advanced reading, to use special scientific words, and they should be encouraged to do so; but there should be no pressure on other pupils to learn them.

Book Five uses relatively few technical words. Those that are used are introduced carefully in the text, and additional directions are given in the page-by-page discussion of this Teachers' Edition. In general, it may be said that before a word is used, the pupils should be given a sound understanding of the object or the condition that the word applies to. Only then should the word be introduced, after which it should be used often enough so that the pupils adopt it themselves in their discussions.

In order that pupils may use Book Five without being handicapped by the mechanics of reading, the reading level has been kept well below that of readers designed for the fifth grade through the use of simple sentences, brief paragraphs, and a controlled vocabulary. *Exploring Science Five* is not a science reader but a study guide. To provide more reading experience, a list of suitable books is included at the end of each unit in this Teachers' Edition. These books are written in varying degrees of reading difficulty and provide for different levels of reading ability.

Teachers who are required to give instruction in the effects of tobacco and alcohol will find suggestions for incorporating such study into the science programme on page 61 of this Manual.

## SCIENCE DEFINITIONS

To facilitate the introduction of certain scientific terms—and for emphasis—they have been set in bold-face type the first time they occur in the text. These 34 terms comprise the special science vocabulary introduced and developed in *Exploring Science Five.* Their definitions are starred in the list below, and the page on which each first occurs is included after the definition. Other scientific terms which appear in the text are also included in the list below; the teacher may wish to give added emphasis to these as well. The language in which all these terms are defined is language which the children will readily understand.

* **adult**—Among insects, the last stage reached by an insect—when the insects produce young. A butterfly is an adult insect; a caterpillar is not an adult but will become one. (page 7)

**almanac**—A type of calendar that gives, besides the days, weeks and years, information about the sun, moon, stars, and other facts.

* **amphibian**—A group of animals including toads, frogs, tree frogs, and salamanders. Most amphibians have gills when they develop from eggs, but lose the gills when they leave the water. (page 306)

**aphids**—Tiny insects that suck juices from plants for food. Most aphids are green, but some are dark, and some are covered with cottony or waxy materials. Aphids are sometimes called "plant lice."

**bacteria**—Tiny living plants found almost everywhere. Some bacteria are useful, as are the kinds that make vinegar. Some are harmful, as are the ones that give us typhoid fever. Most bacteria are harmless.

**cement**—A substance which hardens as it dries and can be used to stick things together. Cement holds bricks in a wall together.

* **circuit**—A path that brings one back to the place where he started. An electric circuit is the complete path along which the electricity flows. (page 156)

* **cocoon**—A silken case made by the young of certain insects before they enter the pupa stage. The caterpillars of many moths spin cocoons of silk thread and change into pupae inside. (page 7)

**concrete**—A mixture of cement, sand, gravel, and water that hardens as it dries. Many sidewalks, roads, and foundations of buildings are made of concrete.

**conductor**—A substance that allows electricity to flow through it. Copper is a good conductor of electricity. Glass is a poor conductor. (page 160)

* **conglomerate**—A rock made up of pebbles and gravel held together with some kind of cement. Concrete is a man-made conglomerate. (page 64)

* **delta**—Mud and sand dropped by a stream where it empties into shallow water. (See picture on page 60.) The Mississippi has made a great delta where it empties into the Gulf of Mexico. (page 60)

**derrick**—A machine for lifting and moving heavy objects. A derrick has a long arm that swings about the foot of a tall mast. (See picture on page 223.)

**digest**—To change certain kinds of food into forms that can be used in the body. In our bodies most food is digested in the stomach and intestines.

**dissolve**—To become part of a liquid, as when sugar is dissolved in water.

* **drone**—The male honeybee. The drone does no work in the hive. (page 18)

* **egg**—The first stage in the lives of many animals. An egg usually contains the part that grows into an animal together with food used by the animal as it grows. In a hen's egg the chicken develops from a tiny white part; the white and the yolk are food for the chicken as it grows. (page 7)

**energy**—The ability to do work. Gasoline has the ability to move an automobile, so we say it has energy.

**evaporate**—To change from a liquid to a gas, as when liquid water changes to water vapour.

**exit**—The way out. Signs saying "exit" in theatres tell where there are ways to leave in case of fire.

**female**—Girls and women are females. Cows are female cattle. A doe is a female deer. (page 282)

**filter**—A device that removes solid particles from a liquid that is being poured through it. (See picture on page 51.)

* **fossil**—Any sign that a plant or animal has lived somewhere in the past. Fossils include shells, bones, prints of shells, and footprints. (page 66)

**fuel**—Anything that can be burned to make a useful fire. Coal, wood, and oil are common fuels.

* **generator**—A machine which, when turned rapidly, sends electricity flowing through a circuit. There is a generator in an automobile that makes the electricity flow through the lights, the horn, and the radio. (page 174)

**gill**—A part of the body of some water-living animals used for taking oxygen from the water. The gills of a goldfish can be seen when the goldfish opens its gill covers on the sides of its head to let water flow out.

* **glacier**—A large mass of snow and ice that flows slowly down a mountainside or valley. There are many glaciers in the mountains of Canada and Alaska. (page 70)

**gland**—Part of the body that makes and gives off a liquid. In the mouth there are glands that give off the liquid called saliva that moistens the food we eat.

* **grub**—The second stage in the life of some kinds of insects such as beetles and ants. It is usually thick and wormlike. (page 7)

**honey**—The thick, sweet liquid made by bees from the sweet liquid they take from flowers.

**honeydew**—The sweet liquid given off by some kinds of aphids.

* **infra-red light**—The invisible part of sunlight that we cannot see but can feel because it makes us warm. Infra-red light warms all objects it falls upon. (page 196)

* **insulation**—A material used to keep heat from flowing through the walls of houses, refrigerators, and the like. Most kinds of insulation are light and fluffy and contain many air-spaces. (page 109)

**insulator**—A substance that does not allow electricity to flow through it. Glass is a good insulator. Wet wood is a poor insulator.

**liquid**—A substance that is neither a solid nor a gas which flows freely like water. Gasoline, mercury, and water are liquids.

* **limestone**—A kind of rock that is made of the same chemicals as are found in clam shells and snail shells. Limestone is often made of such shells crushed and cemented together. (page 65)

**lung**—The part of the body of certain animals where air is taken in and oxygen is taken into the blood. Each person has two lungs in his chest.

**male**—Boys and men are males. Bulls are male cattle. A buck is a male deer. (page 282)

**melt**—To change from a solid to a liquid. Ice melts when it changes to water.

* **meteor**—A mass of stone or metal that comes near the earth and falls through the air, becoming white hot as it falls. It is often called a "shooting star," but is not really a star. (page 154)

* **mite**—A very tiny animal that lives on the bodies of other animals and gets its food by sucking their blood. (page 312)

* **mould**—A plant that often grows on food as a woolly or furry growth. It does not make its own food, but uses that made by other plants. (page 79)

* **nectar**—A sweet liquid found in many flowers. Bees make honey from nectar. (page 22)

* **ovule**—The part of a flower that becomes a seed. (page 277)

* **oxygen**—A colourless gas in the air. Plants and animals cannot live without oxygen. Fire cannot burn without oxygen. About one-fifth of the air is oxygen. (page 41)

* **parasite**—A plant or animal that lives by taking its food from other plants or animals. Fleas are parasites on dogs. (page 312)

* **pistil**—The part of a flower that contains the ovules as they grow into seeds. (page 276)

* **planet**—One of the heavenly bodies that moves about the sun. Venus is a planet. The earth is a planet. (page 100)

* **pollen**—The fine powder, often yellow, that is produced in the flowers of many plants. Pollen must usually fall on the pistil of a flower before the ovules can become seeds. (page 21)

**prism**—A piece of glass that has flat sides and three-sided ends used for separating sunlight or other white light into the colours of the rainbow. (See the picture on page 181.)

**propeller**—The whirling part used on many boats to drive the boat through the water. (See the picture on page 268.)

* **pupa**—The stage in the lives of certain insects when the insect moves little but is changing inside. This stage of life is spent in some kind of case, such as a cocoon. A caterpillar changes into a pupa and then later changes into a butterfly or moth. (page 7)

* **queen**—Among insects that live in colonies, the one insect that lays the eggs for the colony is the queen. The queen does not rule in an insect colony; she does little except lay eggs. (page 8)

**radiator**—A set of pipes or other containers that give off heat, as the hot-water or steam radiators used to heat homes.

**reflect**—To throw back light. A mirror reflects sunlight as a spot on the wall. A lake reflects the colour of the sky.

**rudder**—The part of a boat or plane that steers it. (See page 270.)

* **saliva**—The liquid produced by glands in the mouth. It is sometimes called "spit." Saliva moistens the food we eat and begins the digestion of some kinds of food. (page 86)

* **sandstone**—A kind of rock made of sand held together with some kind of cement. (page 64)

**sap**—The liquid that carries minerals and food through a plant.

* **shale**—A kind of rock made of clay or mud tightly pressed together and perhaps cemented with some kind of cement. (page 65)

**short circuit**—An accidental circuit which is formed when a large conductor cuts out part of a regular circuit and carries most of the current. A short circuit may become so hot that a fire is caused.

* **stamen**—The part of a flower that contains the pollen. (page 276)

**star**—A heavenly body believed to be a sun much like the one we see every day, but so far away that it seems tiny.

**stomach**—The sack-shaped part of the body where food is held while digestion starts. (See picture on page 89.)

**storage battery**—A device in a car for storing the energy of electricity so that one can use the lights, horn, and radio when the generator is not running.

**streamlined**—To be shaped so that water or air flows past easily. Airplanes are streamlined so they slip easily through the air.

**switch**—A device for making an electric current start and stop. The electric lamp in your classroom is turned on or off with a switch.

**thermostat**—A device used to keep the temperature of a place nearly constant. Many home furnaces are controlled by a thermostat. There is a thermostat in an electric refrigerator that starts the motor when the refrigerator becomes too warm.

* **turbine**—An engine in which there is a wheel that is turned by the force of water or steam. Turbines are often used to turn electric generators. (page 174)

* **ultra-violet light**—A part of sunlight that we cannot see or feel but which can tan our skin and give us sunburn. (page 198)

**windlass**—A machine that winds up a rope, cable, or chain to pull or lift something. (See picture on page 227.)

* **workers**—The insects in a hive or nest that do most of the work, as compared with the queens that lay the eggs and the males that do nothing.

# Insects That Work Together

## PURPOSE OF THE UNIT

A few species of insects are highly organized socially. This organization is the result of sets of inherited behaviour patterns rather than the result of conscious thinking and planning. Careful study of the behaviour of these insects helps pupils to understand why scientists try not to interpret the reaction of other living things in terms of human behaviour. They will see, for instance, that these insects respond chiefly to outside forces, whereas man has control of many of his actions and can even bring about changes in the outside forces that act upon him.

Social insects are widely distributed and often play an important role in the plant-animal community. A few of them are important economically to man. Honeybees, for instance, are almost indispensable in the reproductive cycle of many plants. Again, termites have become a serious problem to man in many countries. There is much practical value in knowing the habits and life histories of such insects.

Units in previous books of this Series have established a background for an understanding of the life cycle of insects. This unit continues the study of life cycles. Although social organization and life cycles receive the most attention in this unit, something of the relationship between certain insects and the plant-animal community are noted. Unit 13, "Flowers and Their Work," builds upon the present study of the honeybee.

## PREPARING FOR THE UNIT

In order to use real situations as much as possible, social insects should be studied in spring or in fall when the insects are active. It is suggested that early fall be chosen, it being the time when the insect colonies are at the peak of their development.

A teacher should be on the alert for materials to be used in teaching the unit. Ant colonies are common in almost any situation, including densely populated cities. Most satisfactory for classroom studies are the mound-building ants and the kind that live under stones in woods and fields. Carpenter ants are easy to find where they are present, because of the piles of "sawdust" which heap up at the base of infested trees, posts, or logs. Sometimes it is possible to obtain specimens of the wood that the carpenter ants have been living in.

Numerous ant colonies can usually be found during late spring and early fall, in the school lawn. Such opportunities for observing ants at work should not be missed. Pupils should be encouraged to study the appearance and movements of the insects.

A teacher should try to get in touch with a bee-keeper who might be sympathetic with children, and arrange for a visit to his establishment or for a talk in the classroom about bee-keeping. Sometimes the bee-keeper can arrange for the loan of a demonstration hive.

Paper wasp nests are still inhabited in early fall but they become safe to take after the first severe freezes. Two or three of these nests may be added to the teaching collection for use in coming years.

**List of Materials**

Trowel or small shovel
Glass jar
Pan
Block of wood
Hand lenses

## TEACHING THE UNIT

As much as possible, introduce each group of insects with first-hand experiences. This will be easy in the case of the ants, because ant colonies are easily found near most schools, and because a temporary colony can easily be established in the classroom. Paper wasps may be introduced with a study of nests that have been collected in previous years. Honeybees may be introduced with a study of the honeycomb and any similar materials that may be available.

The material in the text should be followed up with as many additional sources of information as possible. There are many slides, films, and reference books dealing with the social insects, particularly the honeybee. (See BIBLIOGRAPHY pages 32–33.)

The term "larva," as applied to the second stage of the life cycle of many insects, is not used in this unit. The term "grub" is used instead. However, if desired, the teacher may introduce the word "larva" and encourage the pupils to use it. This will help pupils who read references that use the more technical term.

Pupils may have some trouble with the plurals of such terms as "pupa" and "larva." It is now permissible to use such anglicized plurals as "pupas" and "larvas," but few references do. Instead, the children will commonly encounter such words as "pupae" and "larvae" which will look strange to them. It will help, to explain these.

In addition to the word "grub," the following comprise the special science vocabulary introduced in this unit: "egg," "cocoon," "pupa," "adult," "queen," "workers," "drones," "nectar," and "pollen." The first use of each word is noted in bold-face type.

**Pages 4–5**

These pages show colonies of the three groups of social insects studied formally in this unit. The pupils may be asked to find these colonies in the pictures and tell about their experiences with similar colonies.

Use these pages to set the stage for field trips if there are colonies of social insects near by. It is well to caution the pupils about going too near beehives and wasp nests. Bees and wasps seem to be especially irritable at times and will sting any intruder, no matter how harmless the intruder may be. Little boys who love to throw rocks through paper wasp nests will need special control.

**Pages 6–7**

These pages are especially valuable if they are studied in conjunction with field work on similar types of ants. In many fields and waste areas, the pupils may find this type of ant colony under stones, boards, and small logs. When the nest is uncovered, the pupils will see ants carrying pupae and grubs to safety. The eggs are too small to be seen easily. The grubs are nearly white and larger at one end than at the other. The cocoons are somewhat egg-shaped and are generally cream-coloured. The "ant eggs" sold as turtle food are really cocoons with pupae inside.

Encourage the pupils to replace the covering stone or board carefully after they are through watching the ants. Ants are generally harmless and there is no purpose in killing them.

**Pages 8–9**

Plan to establish an ant colony in the classroom. Besides the mound-building type shown here, some of the larger kinds that live under stones are also satisfactory.

It is not always easy to capture a queen ant necessary for a successful colony. However, a colony without a queen will be active for two or three weeks. Pupils will see the activities of the workers and the development of the young ants.

The cage for an ant colony as described on page 9 is simple to make and easy to take care of. (The water round the block keeps the ants from escaping.) There are other types, some containing no soil at all, that permit better visibility. Directions for making such cages are given in many books dealing with the study of insects such as the *Handbook of Nature Study*; see page 157.

When feeding the ants remove uneaten food given previously. Do not let food mould or spoil; spoiling food may harm the ants.

**Pages 10–11**

If at all possible, pupils should study the bodies of living ants as they carry out the work of the first of these pages. Encourage the pupils to make drawings and to describe the activities of the ants in terms of the structures involved.

Winged ants are seen most commonly in summer, but some may be seen in early fall. Sometimes when collecting for an ant colony, the pupils will find a pupa that is a little larger and a little darker than the others. This pupa will produce a winged male or female.

The role of the male in mating is but briefly touched upon in this unit. However, the teacher may explain in more detail the necessity for sperms in the reproduction of most animals.

**Pages 12–13**

Different species of ants have different feeding habits. Pupils will discover some of these food preferences by observing ants outdoors and by experimenting with captive ants. References dealing with ants also give information, although they commonly emphasize the more unusual species. In general, ants utilize some type of sugar for an energy food and obtain their proteins from meat such as dead insects.

As shown in the diagram, ants possess a special "stomach" for carrying liquid food. This is not a stomach comparable to our own which is capable of digesting food. It is instead a "sac" into which liquids can be placed for storage and from which the liquids can be forced out through the mouth as desired. This last act is not to be compared with our regurgitation of digested or partly digested food when we are sick.

Some species of ants obtain their sugar from aphids, often called "plant lice." The aphids take in much more sap than they use. The excess sap, concentrated by evaporation and altered by enzymes in the aphids' alimentary tracts, is excreted. Sometimes it is given off by aphids in such quantities as to make sidewalks, benches and automobiles under trees sticky to the touch. Look for aphids and ants on bushes and low plants. Plan a field trip if some are found. Watch the ants feeding.

**Pages 14–15**

The habits of some species of ants are remarkable. Two such species are described here. Other unusual ants are described in various reference books (see BIBLIOGRAPHY pages 32–33). It should be pointed out that most of the unusual ants live in other parts of the world.

The mushroom-raising ants, pictured on page 15, cut from green leaves small bits which they pile up in chambers in their tunnels. On these heaps of leaves, the ants put bits of fungi that they are able to eat. The fungi grow on the decaying leaves and provide food for the ants.

**Pages 16–17**

A study of paper wasps is made especially meaningful if the pupils can examine some of the nests. One nest should be left intact, but other nests should be opened to show the interior structure. Combs may be taken out and examined, and some of the capped cells may be opened to show the contents. Sometimes specimens of the various stages may be found in the cells.

Should an adult wasp fly into the classroom, capture it by inverting a drinking glass over it. The pupils may then study its external appearance safely. (The kinds of wasp that build paper nests are often called hornets.)

**Pages 18–19**

The life history of honeybees is treated in many books with more detail than is possible in this volume. Try to provide the pupils with a wide selection of these books for reference.

Try to use first-hand experiences as much as possible. In large cities, a teacher may be unable to do more than buy a comb of honey, but the examination of a honeycomb raises many interesting problems that reading will solve. In rural areas, it is usually possible to show the children an empty hive, a brood comb, and honey extraction equipment.

**Pages 20–21–22–23**

When studying the queen bee, explain that the term "queen" is not appropriate in the sense of royalty. The queen bee has no special authority. She is, instead, more like an egg-laying machine. A better term for her would be the "mother bee."

The text mentions the special cells and the special food provided for the developing queen bees. Apparently these factors determine whether or not certain eggs become workers or queens. Both workers and queens are females but the former are sterile. If, however, an egg or a newly hatched larva is taken from a worker cell and placed in a queen cell, a queen develops.

Males, on the other hand, come from different, unfertilized eggs. It must be that the queen can control the fertilization of her eggs because she lays the unfertilized eggs only in the special cells made for drones.

Encourage the pupils to read about the organization within the hive and to report on their readings. Be always alert to point out that the organization is the result of inborn reactions and thus cannot be interpreted in terms of human social organization. If any reference books err in this respect, do not hesitate to challenge the books.

### Page 24

Pupils will be greatly interested in the "sting" of a bee, but it is usually a morbid interest. Make light of the effects of being stung; it is rarely serious although painful for a short time. Pupils will probably want to know whether the bee dies after stinging someone. In general, a bee does die after stinging a human or a large animal because the sting does not withdraw easily; frequently the sting is torn from the bee's abdomen.

#### Summary Questions

1. Ants, like other insects with complete metamorphosis, go through four stages—egg, grub (larva), pupa, adult.

2. Among the ants that have been carefully studied, the queen ant is the only ant that lays eggs. There may be exceptions. It has been discovered that workers of the paper wasps will lay eggs if the queen is destroyed. It is always dangerous to make generalizations about insects.

3. It is to be hoped that the pupils will have seen ants carrying things in their jaws and can answer this question from first-hand observations. Otherwise they must depend upon the pictures on pages 7 and 10. They should also describe the special storage stomach used for carrying liquids.

4. Usually when winter comes all paper wasps die with the exception of the new queens. These queens winter in sheltered places and establish new colonies in the spring.

5. Under natural conditions, the wax for the combs comes from glands located on the under side of the abdomen of the workers. This

process requires the time and energy of many workers and uses up (as food) much honey that could otherwise be put into the comb. Most bee-keepers extract the honey from the honeycomb before selling it. The wax is then processed to form the foundation for more honeycomb. Thus the bees do not have to produce new wax for the whole comb.

6. The duties of worker bees are many and varied. Among others, they feed and care for the queen, build brood combs and honeycombs, feed and care for the larvae, collect nectar and pollen, produce wax, change the nectar into honey, ventilate the hive, and guard the colony.

7. Paper wasps make paper by chewing off bits of weathered or rotting wood and moistening them with secretions from their mouths. They then stick the fibres together in a thin sheet.

### Follow-up

Ant colonies established in the classroom permit continued observations. If a colony contains a queen, it may be kept active through the winter and observed from time to time.

If the work of termites is discovered, time should be taken to study these interesting animals. It should be pointed out here that termites, although resembling ants in some ways, are actually unrelated to ants.

When leaves drop from the trees, it is time to look for the nests of paper wasps. After several hard freezes, the nests may be collected and brought into the classroom.

The slack winter season may be a good time for a bee-keeper to show the class some of the materials he uses in the production of honey. Then when spring comes, there will be numerous opportunities to observe social insects again.

## POSSIBLE LEARNINGS

Bees, ants, and wasps pass through four stages in their lives.
Honeybees, ants, and paper wasps live in colonies.
The members of an insect colony have different duties that help the others in the colony.

## BIBLIOGRAPHY

### Books

*Boys' Book of Insects.* Edwin Teal. Smithers & Bonellie: Toronto, 1939. 273 pages.

Has valuable material on ants, bees, and wasps.

*First Book of Bees.* Albert Tibbets. Ambassador Books: Toronto, 1952. 68 pages.
The story of honeybees—how they live, work and help us.

*First Book of Bugs.* Margaret Williamson. Ambassador Books: Toronto, 1949. 44 pages.
A text that gives food, habitat, habits, and enemies of common insects.

*Insects.* Herbert Zim. Musson: Toronto, 1951. 157 pages.
A guide to familiar American insects.

*Insect Societies.* Bertha Parker and Alfred Emerson. Copp Clark: Toronto, 1941. 34 pages.
A brief description of the way insects live.

*Our Insect Friends and Foes and Spiders.* National Geographic Society: Washington, D.C., 1935. 252 pages.
Contains background information. Illustrations will interest pupils in any grade.

*Introducing the Insect.* F. A. Urquhart. Clarke, Irwin: Toronto.

**Films**

*SN-7 Life of the Ant.* Ontario Department of Education.

*SN-39 The Honey Bee.* Ontario Department of Education.

*Insect Zoo.* Encyclopaedia Britannica Films.
Close-up photography of ants and other common insects—for a young audience.

# Controlling Fires

## PURPOSE OF THE UNIT

Fire is a major factor in our lives—indispensable, but always dangerous and sometimes devastating. Its control is a serious problem, not just to a few specialists, but to every one of us, young and old alike. And while the lives of young people no longer depend upon their ability to build fires, they use fire constantly, and it is our duty to see that they understand and respect it.

This unit is part of the carefully planned sequence of safety education in this Series. It stresses both the prevention of fires and the proper conduct of children when fires are discovered. The unit also plays a part in the sequence of conservation material emphasized in this Series. There is no way in which children can participate in the conservation of our natural resources more effectively than by preventing their waste through fire.

In terms of subject matter, this unit is part of the sequence on chemical changes. It builds directly on the unit "Fire and Air" in *Exploring Science Three*. It is also a part of the heat energy sequence and it helps to develop a broader understanding of air and gases.

Most of the information given in the unit can be obtained by observation of real situations. It helps to develop the habit of turning to experiment and to first-hand experiences for the ultimate authority, while depending upon such supplementary sources as books for broadening understandings.

## PREPARING FOR THE UNIT

Fire Prevention Week, which usually comes in the fall, is a big event in some communities. Fire departments put on demonstrations, provide speakers, and conduct trips. Insurance companies and safety councils supply booklets, charts, films, and other visual materials. This unit is greatly enriched by, and enriches in its turn, the activities of Fire Prevention Week.

If Fire Prevention Week is not observed in the community, it is still possible to obtain help from most local fire departments. And, of course, booklets and other free materials are obtainable from insurance companies at any time.

Local conservation groups, such as sportsmen's organizations, are often interested in forest fire prevention. They will usually provide booklets and charts that can be used with this unit. Information can also be obtained from Provincial Departments of Lands and Forests.

Scout groups may be willing to put on demonstrations of fire building and fire safety. They may also have materials on fire prevention. Many boy scouts and girl scouts know one or more methods of starting fires without matches; perhaps some demonstrations can be arranged.

Plan, if at all possible, to go outdoors for demonstrations of fire building and extinguishing. A picnic presents an excellent opportunity for applications of the principles studied here.

List of Materials

Candles
Matches
Spoon

Cloth
Hand lenses
Bit of copper screening
Bare copper wire
Hot-plate or other source of heat
Metal can with tight-fitting lid
Sawdust or chips of wood
Pieces of soft wood
Glass jars
Fire extinguisher

## TEACHING THE UNIT

The unit is flexible and its various topics may be rearranged to fit the immediate situation. Parts of it may be taught at different times of the year. For example, Fire Prevention Week may come during a period of good weather that is needed for other units. In this case, it is possible to take up the safety aspects of fire prevention first and to consider the remainder of the unit at some later time.

Because of safety problems, the experiments suggested in this unit should probably be carried out as demonstrations, either by the teacher or by selected pupils. A fire extinguisher should be available at all times, not because the experiments are dangerous but because the pupils should be impressed with the necessity of taking no chances.

The word "oxygen" is introduced in this unit. It is not an easy term to teach because oxygen is a colourless and odourless gas that does not reveal its presence even though it is plentiful in the atmosphere. However, it is such an important element, and pupils hear so much about it, that it is desirable to begin to acquaint them with it at this time. The word "oxygen" has been emphasized the first time it occurs in the text.

### Page 25

The title page may be used to stimulate discussion of fires that the pupils have built and have seen built on camping trips or picnics. The pupils may tell about the uses of such fires. Out of this discussion may develop a discussion of other uses of fire. Perhaps the children will like to list as many uses as possible.

### Pages 26–27

We introduce first the concept that heat is needed to start fires, but we limit discussion to the lighting of a candle at this time. Pupils may wish to extend the concept to include other types of fires with which they are acquainted. A few pupils may insist that there are exceptions in the cases of fires caused by "spontaneous combustion" and in a sense they are correct, but there is heat involved in these cases too, heat from decomposing hay or oxidizing oil. The fires that we deliberately start, however, are always started by heat applied from the outside. In the case of the candle, some of the heat is used to melt the wax and some is used to evaporate the wax, as will be considered on the next two pages. The "smoke" mentioned in the text is a cloud of tiny particles of condensed wax vapour. It is discussed more fully in the next paragraph.

**Pages 28–29**

Be sure that the pupils realize that cool wax does not burn. Then show them that heat energy melts and evaporates the wax. The white "smoke" referred to is not truly wax vapour, which is invisible. It is a cloud of tiny drops of condensed wax vapour. It is something like the "steam" over boiling water.

Pupils can be shown that wax does evaporate by holding a cool piece of glass or metal over the heated wax. Wax vapour condenses on the cool surface as a thin film of wax.

Pupils can be shown that liquid wax does not burn by holding a lighted match over it after it has first melted. Only after the wax has been heated still more will it produce a flame.

The safety aspect of heating paraffin and other waxes should be mentioned at this time. When large quantities are heated, as is the case when making jelly, one should be careful about heating the wax too much lest a large amount of vapour be produced. People have been badly burned by having the vapour ignite.

The concept of cooling a fire to extinguish it is introduced here. In this case, cooling puts a stop to the production of wax vapour and the flame is extinguished. This concept will be developed on succeeding pages.

**Pages 30–31**

Here we find two more ways of cooling a flame: by taking heat away with metal, and by blowing cool air on the fire. Copper screening works best in the first experiment because copper is a good conductor of heat. In this case the flame beneath the screen produces enough energy to melt and vaporize wax, but the screen cools off the vapour passing through the screen so that it does not burn. Of course, if the screen becomes very hot, the vapour that passes through it will be ignited.

The second experiment uses a coil of wire in place of the screen. Again copper is best for the wire because it is a good conductor of heat. Make the coil small, just a little larger than the wick. Hold it in the flame. It will absorb enough heat to extinguish the flame.

After the experiment showing that cool air extinguishes a candle flame, pupils will probably recall that people often blow out matches, and that wind blows out matches and other small fires. Some pupils may object that blowing on a fire makes it burn faster, but in such cases the fires are large compared with the volume of air blown on them.

**Pages 32–33**

Wood flames are much like candle flames in that each is the result of a burning gas. Because a candle flame arises from a single point it may be more regular than a wood flame, but otherwise its structure is much the same.

Unlike the candle flame, however, a wood flame does not result from simple evaporation. Rather, the heat that is applied to the wood causes chemical changes that produce a gas. It is this gas that burns. At the same time, small amounts of tars are produced. These tars evaporate and burn if there is a hot flame. The tars are the cause of the odour and the eye-stinging qualities of wood smoke when a fire is not hot enough to ignite them.

It is well to experiment a bit with the production of gas from wood as described on page 37. Obviously, the more heat that can be applied to the can, the faster the wood will break down into gas and tar and charcoal. Try different quantities of wood shavings also; a large quantity may not heat up fast enough. A good source of wood shavings is the school shop; shavings from soft woods, such as pine, give good results; but other things, even pencil shavings, can be used.

**Pages 34–35**

If possible, demonstrate fire-building outdoors on a fairly large scale. Show the children how easily excelsior starts to burn and compare it with a solid block of wood. Build up a campfire in several different ways, using fine wood in some cases and coarse pieces in others.

If wood fires are used at home in fireplaces, in stoves, or for starting coal fires, ask the pupils to report on the means used to start the fires. Paper is often used as tinder; call the attention of pupils to the fact that paper is made of wood fibres.

**Page 36**

Pupils should have little difficulty in understanding how the "strike anywhere" type of match is ignited. They may wish to know more about the matches and may be referred to encyclopedias. They will find that the tip contains a phosphorous compound that ignites at a comparatively low temperature. The next part of the match contains sulphur which ignites at a higher temperature but gives off enough energy to ignite the wood. With the sulphur there is usually another chemical, potassium chlorate, that gives off oxygen when heated. This oxygen makes the sulphur burn faster.

Pupils may be curious about matches that will light only when scratched on a special surface. The tips of these matches contain sulphur and potassium chlorate. A phosphorous compound is mixed with the sand of the scratching surface. When the match is scratched, a little of the phosphorus rubs off on the sulphur, ignites, and sets fire to the sulphur. These matches are called "safety matches."

**Page 37**

Building fire without matches is interesting to children who have never seen it done. Perhaps a scout can demonstrate the process. Reading about this method of fire building sometimes results in misconceptions if the actual process is not seen. The methods have varied over the earth but in general the energy needed to ignite the tinder comes either from the friction of rubbing or from the pressure produced by a sudden blow.

**Pages 38–39**

Liquid water in a fuel cannot be made hotter than 212 degrees. At this temperature wood does not change into gases and charcoal, and so it does not burn. Water in fuel, therefore, must be removed before the fuel will burn. Often much of the energy needed to start a piece of wood burning is used to evaporate water from the wood. Pupils who have built campfires probably know how difficult it is to build a fire with wet wood or with "green" wood. If possible, build fires using dry wood, water-soaked wood, and green wood in this order.

Water poured on a fire may cool the fuel to a temperature below that needed for the production of gases. The fire is then extinguished. Be sure the children understand the reason why water is so effective.

Then be sure that every pupil knows how to extinguish a fire properly; most children today build fires at one time or another and they should know the elementary precautions.

**Pages 40–41**

An experiment suggested in the unit "Fire and Air," in *Exploring Science Three* is repeated here, but is given new meaning by the introduction of the concept of oxygen. A candle can burn well in a closed jar after it is first lowered inside. Soon, however, the candle is extinguished.

There is no way for pupils to discover what takes place in the jar except by being told. All the gases in the air are invisible including the oxygen that is used and the carbon dioxide and water vapour that are produced. The concept of oxidation must be developed solely on the authority of the text and the teacher.

Many people believe that a candle will burn until all the oxygen has been removed from the air, but actually the flame dies before half of the available oxygen has been used. This is because the speed of burning decreases as the concentration of oxygen decreases. When heat is not given off fast enough to keep the gas burning, the flame dies. Watch a candle flame closely as it burns in a glass jar; soon the flame grows longer and particles of carbon begin to fly from it, too cool to ignite. Then the temperature drops still more until the other chemicals in the flame cannot ignite.

Extinguishing fires by "smothering," that is by keeping away a supply of oxygen, is used for small fires. The cigarette lighter shown is one application and a candle snuffer is another. Burning clothes are extinguished by wrapping the wearer in a blanket or rug. Small fires in the woods are successfully controlled by covering them with soil.

**Pages 42–43**

The cheapest and easiest way to give a fire more oxygen is to increase the air supply coming to it. Normally, a large fire creates its own draught by heating the air over it, as is described on page 43. Sometimes, however, if the fire is small and the air is damp, an adequate draught is not established. We may then blow on the fire, or fan it, or use bellows. Sometimes we may let the wind help us. If it is possible to build a fire outdoors, demonstrate these different methods of increasing the supply of air.

Fires in stoves and furnaces produce a draught in the chimneys attached to them. This draught supplies oxygen and can be controlled so that the fire can be made to burn rapidly or slowly. If the school heating plant has a natural draught air supply, take the class to see it. The draught can be demonstrated by holding strips of thin paper near the openings of the furnace.

Some furnaces have blowers that supply air to the fires. If possible visit one of these furnaces to see how the blower operates.

**Pages 44–45**

The exact procedures for reporting a fire vary somewhat with the type of fire department and the type of signal used. Rural communities may use only the telephone. Cities may have both telephones and fire-alarm boxes. In planning lessons on this subject, it is well to contact the local fire department and ask for the preferred procedures. Sometimes the fire chief will send a person to the school to help to show how to report fires. Practise reporting fires as it is done in your community.

Two other emergencies are discussed here. The procedure for extinguishing burning clothing can be demonstrated. A visit to an auditorium will show how the EXIT signs indicate doors to be used in an emergency.

Additional emergencies may be considered: burning fat in a frying-pan, a small grass fire, and a smouldering fire in a wastebasket. It is usually well to take these up in co-operation with the local fire department or safety council.

**Pages 46–47**

On these pages are given six situations that pupils can help to control. (1) Papers should be burned in wire baskets or in closed incinerators so that the wind will not blow bits of burning paper about. (2) Fireplace screens prevent sparks from snapping out on rugs and floors. (3) Small children might ignite matches and set fire to their clothing or their surroundings. (4) Papers and other inflammable rubbish may become ignited through carelessness and they may be difficult to extinguish because of the speed with which they burn. (5) If an electric lamp cord under a rug is walked on enough the insulation breaks down, thus permitting a short circuit that may set fire to the rug. (6) Gasoline evaporates quickly. The vapour may spread through a house and ignite when it reaches any open flame.

The pupils should be able to think of many other precautions. The disposal of cigarette butts and newly extinguished matches should be considered. The dangers of keeping inflammable materials other than those mentioned here should be stressed, particularly those oils that evaporate readily. Dry cleaning fluids that evaporate and burn should be discussed together with precautions for using them. Booklets provided by insurance companies and safety councils will suggest additional items of importance.

A home survey of fire hazards is valuable. This may be carried out in co-operation with the local fire department.

**Page 48**

Precautions for building a campfire are given here. Try to arrange for a demonstration of safe procedures. Encourage the pupils to think of other ways to help to prevent forest fires such as proper disposal of matches and cigarette butts, spark elimination, dangers of burning dead grass in fields, and so on. The pupils may also be interested in studying forest fire control by public agencies.

### Summary Questions

1. A fire has three requirements—something to burn, heat to start it burning, and oxygen.
2. A flame is a burning gas.
3. Usually we start a match burning by rubbing it on something rough so that friction heats it. We can also start a match burning by touching it to something hot.
4. Pupils should know the procedures described on pages 35, 39, and 48.
5. In addition to the precautions described on pages 46–47, pupils should list others that come both from their discussion of the subject, and from pamphlets and charts that are available.
6. Pupils should describe the method of reporting a fire that is preferred by the local fire department.
7. Pupils should know that the word EXIT means a way to leave a room or building and is usually applied to doors to be used in emergencies.

### Follow-up

There are many times in a science programme when pupils light matches, experiment with things that involve fire, and read about the effects of fire. On any of these occasions, it is possible to review briefly some of the principles that have been developed in this unit.

The safety aspects of fire should be reviewed several times, both formally and informally, as events point up the necessity for constant caution. Newspaper accounts of local fires often give suspected causes; clippings should be put on the bulletin boards. Insurance companies often publish statistics on the causes of fires. These may be brought to the attention of the children. Forest fires occur mostly in fall and spring but any dry season will bring them on. Their occurrence should be noted together with causes if these have been determined.

Sometimes unusual opportunities to learn about fires present themselves. A forest ranger is willing to speak to the class. A film dealing with fire protection becomes available. A new type of fire extinguisher is to be demonstrated. It is not necessary that the class be studying this unit to take advantage of such opportunities; such learning situations are effective at any time through the year.

## POSSIBLE LEARNINGS

Fire has many uses.
Heat energy is needed to start fuels burning.
Flames are burning gases.
Fires can be extinguished by cooling the fuel.
Fires need oxygen in order to keep burning.
Fire can do much damage and injure people.
It is easier to prevent fires than to put them out.

## BIBLIOGRAPHY

### Books

*Big Fire.* Elizabeth Olds. Thomas Nelson: Toronto, 1945. 32 pages.
Gives a history of fire-fighting from colonial times to the present.

*Fire.* Bertha Parker. Copp Clark: Toronto: 1941. 35 pages.
Brief descriptions of the physical properties of fire.

*Fire Fighter.* Henry Lent. Brett-Macmillan: Toronto, 1939. 65 pages.
Gives an idea of firemen, fire-boats, and fire prevention in New York City.

*Fire, Friend and Foe.* Bertha Parker. Copp Clark: Toronto, 1941. 35 pages.
Story of fire, including information on fire prevention.

**Films**

*Fire.* Encyclopaedia Britannica Films. Ontario Department of Education: SG-9.
Essentials of combustion illustrated by animated drawings; shows effective methods of extinguishing fires.

*Fire Making.* Encyclopaedia Britannica Films.
Answers many common questions about fire.

*Flashy the Fire Bug.* National Film Board.
*SN-92. Temagami Ranger.* Ontario Department of Education.

# Streams at Work

## PURPOSE OF THE UNIT

Running water is one of the most active of all erosional agents. Nearly every locality has several features that are the result of stream erosion. And of all the erosional agents, running water is one of the easiest for pupils to study. It well deserves a prominent place in a well balanced science programme.

Stream erosion was introduced in the third-grade unit, "Muddy Water." The emphasis at this early level was on the erosion of loose materials. The fourth-grade unit "Soil" touched upon the formation of soil from materials eroded by stream action from rock. The present unit considers the mechanics of stream erosion, some major changes in the landscape resulting from such erosion, and the transportation and deposition of sediments. On the foundation established by these three units is built the sixth-grade conservation unit, "Saving the Soil," which makes use of principles developed in the earlier grades.

The present unit "Streams at Work" encourages an interest in the topographic features of the neighbourhood. Good science teaching always goes beyond the four walls of the classroom into the out-of-school lives of the children, encouraging them to observe, to speculate, and to apply principles studied in their classes. This unit permits extensive field work on both a class basis and an individual basis, and it encourages special interests and individual initiative.

# PREPARING FOR THE UNIT

It is well to take up this unit when the weather permits field work by classes during school hours and by individuals during out-of-school time. Early fall is an appropriate time in most sections of the country because field conditions are usually suitable at this time.

The teacher should spend as much time as possible becoming acquainted with the geography of the neighbourhood, because the more the teacher knows about the topographic features the richer the unit can be made. Short walks to nearby ponds and streams often reveal excellent teaching situations, some close enough for class trips, and all usable as reference. These topographic features need not be large and spectacular. Sometimes seemingly minor features make excellent teaching aids. A ravine may illustrate stream action as well as, or better than, the Grand Canyon, and certainly a tiny delta in a nearby pond is easier to study than the delta of the Mississippi.

Within a few miles of many communities there are parks to which the pupils often go with their parents or with scout groups. These parks may contain streams, ponds, and lakes. Class trips to them may not be possible because of transportation problems, but the teacher may refer to conditions that exist in these areas which are likely to be places familiar to the children.

Pictures represent another means of extending experiences. Photographs of situations familiar to the pupils are especially valuable. Postal cards and promotion booklets often contain such pictures, which may be used for bulletin board displays around which class discussion can centre.

Most of the equipment called for by this unit is easy to secure. Screw-capped jars, pans, drinking glasses, metal cans, and the like are used in other units as well as this one. A gallon battery jar or paste jar is needed for the experiment suggested on pages 58–59. For making a model delta, as described on page 61, a pan such as a baking-pan represents a lake or pond, and a shallow tray of sand represents the land surface. The tray can be constructed by turning up three edges of a sheet of metal, or one end can be cut from an old cookie tray.

Page 62 suggests that the pupils make concrete. For this, some Portland cement is needed. It is not well to buy a whole bag, because the cement deteriorates in storage. Buy some from a broken bag if possible. Often the small amount needed will be donated by merchants or builders.

It is desirable to have labelled specimens of common rocks and fossils. The most useful specimens are those collected locally because these help pupils identify their own specimens. If a teacher does not feel capable of making such identifications, she may turn to local authorities—science teachers and people who have studied geology. Specimens may also be purchased, although these rarely resemble closely the local forms. However, purchased specimens help to extend the experiences of the pupils. Commercial sets of rocks, minerals, and fossils have their greatest use in providing interest for those pupils who wish to go further than this book suggests.

While preparing for the unit, a teacher should not forget to inquire about people in the community who have hobby interests in geology. Such people often delight in sharing their interests and will help the teacher by suggesting places for trips, by providing specimens for study, and by working with interested pupils.

**List of Materials**

Hammer
Quart jar with screw cap
Gallon jar
Drinking glasses
Pans
Tin cans
Tray made of a sheet of metal
Sand
Gravel
Portland cement
Rock and fossil specimens

## TEACHING THE UNIT

Ideally, this unit should be based upon a study of local situations, the book being used to bring the experiences of the pupils into a logical organization. Pictures and specialized books can then be used to broaden the experience of pupils, thus strengthening generalizations and providing opportunities for application of the principles developed. This is the natural direction for learning—from the specific toward the general.

The content of the unit permits extensive use of the problem-solving approach which, when properly used, is one of the most successful teaching techniques. It is essential, however, that the problems be pupil problems and not adult problems. The problems should be specific and related to the pupils' experiences. In one locality, pupils will be interested in the problem, "Why is McAdam's Pond filling up?" when they would care very little about the development of the Nile delta. In another community, pupils would be interested in learning "What happened to the waterfall in Kenny's gorge during the last flood?" although they might care little about the spectacular retreat of Niagara Falls since the ice age.

A teacher needs a stock of such specific problems at the beginning of a unit. However, interested pupils quickly raise a multitude of questions that suggest more problems— some suitable for class work, others better for individual research.

The following are the special science terms which have been emphasized on their first occurrence in this unit: "delta," "conglomerate," "sandstone," "shale," "limestone," "fossils," and "glaciers."

### Page 49

The title page may be used to initiate a discussion of the things that streams can do. Some pupils may think in terms of economic values, mentioning streams as waterways and as sources of power. Others may think in terms of soil erosion, talking about the transportation of soil from fields and banks. Other pupils may think in terms of floods, describing the damage to property in time of high water.

During the discussions, it is well to have the pupils talk in terms of their own experiences as much as possible. Then, following a summary, they may play to build up bulletin board exhibits or class notebooks on the subject, "What Streams Do."

### Pages 50–51

The activity described here is basically the one suggested in Book Four, but it is varied by the use of the filter to recover sediment from the water. The experience is sufficiently valuable to bear repetition, and it serves as an excellent introduction to the subject of rock erosion.

The best rock to use is shale, soft limestone, or a sandstone that breaks up easily. If these rocks are not available, pieces of soft brick give good results but are further removed from real situations.

The more the pieces of rock are shaken in the bottle, the more pronounced are the results. Some teachers ask each pupil to shake the bottle twenty-five or fifty times. After all pupils have participated, the rocks have become well worn. The jar also shows the effects of erosion in the scratches on the glass.

### Pages 52–53

These pages apply the principle of rock erosion just developed. Note the introduction of the energy concept to stream action. Pupils may talk in terms of the energy of streams, great in the case of rapid streams, small in terms of slow-moving streams.

If possible, visit swift-flowing streams to see the results of erosion. Waterfalls, even small ones, usually have well-developed plunge basins. The stones in these plunge basins are usually well-rounded. Rocky gorges may show the effects of erosion in the smooth nature of the stream bed and in the rounded shape of loose stones.

Pictures should be used to extend the experiences of the pupils beyond the material in the text.

### Pages 54–55

The diagrams on these pages, supplemented by the picture on page 52, describe the deepening and widening of stream beds by the water that flows through them. As much as possible, the work of these pages should be enriched by reference to local features and by field trips.

The processes described are slow, requiring many years before there are obvious changes. The soft rock under a falls may erode a decade or more before the hard rock above is weakened enough to break off. The piece that falls to the pool at the base of the falls may persist for many years before it is completely broken up and washed away.

A stream that is winding back and forth in its valley may occupy the same channel year after year. Eventually, however, something will happen to change its course. The undercut bank may slide down, damming the stream and diverting it to a new channel. Sometimes a jam of logs or other driftwood serves as a temporary dam. Often during a flood, when the stream overflows its banks, it erodes a new and shorter route across the curve.

Photographs of actively-eroding streams help in the study of these pages. Pupils should point out in the pictures those places where erosion is probably most active. They may make labelled diagrams based on these pictures and display them on the bulletin board.

Newspapers often contain accounts of changes in waterfalls. Any change in the falls at Niagara is considered news. Such accounts make good bulletin board material.

There are excellent films on stream erosion that may be used at this time. See BIBLIOGRAPHY page 52.

### Pages 56–57

The picture story on these pages describes the effect of continued stream erosion. The period covered might be from 10,000 to 20,000 years. The pupils may tell the story as shown and then speculate on the effect of continued erosion over another equal period. They may draw pictures to illustrate their speculations.

Pupils do not usually think of the valleys about them as continually changing. Encourage them now to consider the valleys as being the result of continued erosion. They might imagine what the region looked like a few thousand years ago and what it might look like a few thousand years in the future.

The development of valleys through stream erosion can be illustrated with a pile of sand. Let a gentle stream of water from a hose or a jug trickle down the side of the sand pile for a considerable time. Valleys will form, deepen and widen, much as is described on these pages. Many pupils become greatly interested in the dynamics of erosion on a sand pile.

### Pages 58–59

Raise the problem of what happens to eroded materials. Pupils will probably assume that eroded materials are swept along by the streams, but they may have no suggestions as to the ultimate fate of the materials. The experiment on these pages illustrates the mechanics of deposition.

Garden soil may be used for this experiment, but it is better to prepare some mixed sediments. Mix pebbles, coarse sand, and fine sand. There is usually enough clay in the sand to make water slightly muddy, showing that very fine material does not settle out rapidly, even in quiet water.

It may be possible to visit stream beds at low water and note the sediments that have been dropped as the water slowed down. Coarse materials will have been dropped where the water was originally swift; sand and gravel, in quieter portions of the streams; and mud, in pools cut off from the main stream as the water level lowered.

### Pages 60–61

Deltas form where streams enter shallow bodies of water. If there are stream-fed ponds in the locality, be sure to look for a delta. A trip to study such a feature is worth hours of discussion about the Nile delta. Pupils are able to see for themselves the conditions that produce deposits at the mouths of streams.

The diagrams on these pages help to explain the mechanics of delta formation, and the experiment suggested here describes the process vividly.

**Pages 62–63**

Few people consider that concrete is a rock, but it has all the characteristics of a natural conglomerate. An understanding of concrete helps in an understanding of many natural rocks.

Directions for making concrete are given in detail on page 62. The mixture should be poured into a can to let it harden. The cement called for is Portland cement, the type used today in most construction. Pupils who wish to know more about Portland cement should be referred to encyclopedias.

The directions suggest the construction of a concrete flagpole holder, but the pupils will probably have many other ideas which may range from a door stop to a bird bath. However, it is well to limit them to something simple because the construction of complex moulds may require expert help.

The concrete will slip more easily from the moulds if the moulds are first coated with oil or grease.

Within a short distance of most schools there are many things built of concrete. It may be worth while to take a trip to discover these applications. Should construction be going on, the pupils will benefit by a trip to see the processes involved. If a mixer is being used, the pupils can see the gravel, sand, cement, and water being put in and stirred, much as they did on a small scale.

**Pages 64–65**

These pages give a brief description of the formation of four common sedimentary rocks. Should these rocks be native to the region, use local specimens for reference during discussions. Otherwise, use specimens that have been purchased or picked up from other regions.

Call attention to the similarity between conglomerate and concrete, using actual specimens. Make some sandstone by mixing coarse sand with a little cement and water. Compare the result with natural sandstone. Make some weak shale by packing wet clay tightly and letting it dry. Make some limestone by cementing whole and broken shells with a little Portland cement.

If possible, take a trip to collect sedimentary rocks. Bring back specimens and label them for exhibit. Exhibit interesting sedimentary rocks from other regions.

### Pages 66–67–68–69

By definition, fossils are any signs of the former presence of living things. Fossils include shells, bones, imprints of shells, tracks, and altered remains such as coal. In older rocks, it is rare that actual remains are found. With the passage of millions of years, such things as shells, bones, and wood are usually altered in chemical structure although they may retain an outward appearance of the original materials.

Pupils are often interested in fossils. In regions where there are fossil-bearing rocks, pupils can make extensive collections with a minimum of encouragement.

One may have interesting lessons about fossils without actually naming them. The pupils may decide upon the parts of the organisms that are preserved. They may speculate about the conditions in which the plants and animals lived. They may discuss the ways in which the organisms may have been buried. If some of the fossils can be classified in such generalized groups as "clams" and "snails," the pupils may study the life histories of living representatives of the groups to gain some idea of what the ancient forms were like.

Sometimes there are people in the community who can help with fossil study. If there is a museum, there will certainly be one or more staff members who can give assistance.

Some scientific supply houses have exhibits of common fossils with information about the life history, the period of existence, and the means of fossilization of each specimen included. These exhibits help with the study of local fossils.

### Page 70

A glacier is, in a sense, a stream of ice flowing slowly down the slope it rests upon. As snow piles up to great depths, the bottom layers are compressed into ice by the great pressure, and if the depth is great enough the ice becomes somewhat plastic. If on a steep mountainside, the ice begins to flow downward.

As the ice moves it flows around and picks up loose rocks. These it carries along rubbing them along the bed-rock. Thus a glacier is able to erode its bed, even as a stream of swiftly-moving water erodes its bed. Although the former process is slower it produces spectacular results.

Glacial erosion is a prominent feature of the landscape in most parts of Canada. Pupils who live in these areas may wish to study glaciers in some detail. In regions where the effects of glaciation are not readily apparent, this topic may receive only passing attention, according to the interest shown by the children.

### Summary Questions

1. The pupils should be able to answer this question in terms of the experiment on page 50 describing how loose rocks wear both themselves and the stream bed when they are tumbled about by rapidly-moving water. They should realize that clean water alone does not erode: water must have tools to work with.

2. Pupils should be able to describe the action of a stream flowing down a slope, including both the deepening and widening effects.

3. A simple explanation of delta formation may include only the statement that rock materials in a stream are dropped when the stream slows down as it reaches a quiet body of water. It is to be hoped, however, that the pupils can go a little further in describing how coarse materials are dropped first and how fine materials are carried farther out from the mouth of the stream.

4. Pupils may describe how they made concrete or how they saw it made by construction workers. Exact proportions are not important at this level.

5. Sandstones are formed by the cementation of sands by natural cements brought by underground water. Usually this takes place at a considerable depth under the surface. Pressure may help to compact the sand slightly, but it is not as important a factor as it is in the formation of shales from clay.

6. In a broad sense, a fossil is any indication of the former presence of some living thing. Usually, however, we think of a fossil as being the indication of some organism that lived long ago.

## Follow-up

In most regions there are numerous possibilities for field study, but time may not permit all of them to be utilized. Sometimes field trips may be scattered through the year. Sometimes pupils may be encouraged to visit interesting sites on their own and report back to the class. Sometimes trips with other objectives can be broadened to include work on erosion. All such possibilities have value at any time through the school year.

New photographs and diagrams continually appear in magazines and newspapers, illustrating principles discussed in this unit. These may be clipped and put on the bulletin board at any time through the year. Such clippings review learnings and renew interest.

## POSSIBLE LEARNINGS

Running water has energy.
Running water containing bits of rock, erodes the stream bed.
Streams tend to deepen and broaden their channels.
Valleys are usually caused by stream erosion over long periods.
Rock materials carried by streams are dropped when the water slows.
Deltas result when sediments are dropped in quiet water by streams.
The bodies of organisms buried in sediments may be preserved as fossils.
Streams of slowly-moving ice wear away the rock underneath.

## BIBLIOGRAPHY

### Books

*Audubon Nature Bulletins.* Prepared and published by National Audubon Society: New York. 4 pages.

Several of the bulletins contain background information to supplement this unit. List sent by the Society on request.

*Picture Book of the Earth.* Jerome Meyer. Ambassador Books: Toronto, 1947. 47 pages.

Answers many questions about rocks and soil.

*Rocks, Rivers, and the Changing Earth.* Herman and Nina Schneider. S. J. Reginald Saunders: Toronto, 1952. 181 pages.

A book which explains the story of our earth.

*Water, Water Everywhere.* Mary Walsh. G. R. Welch: Toronto, 1953. 48 pages.

Describes the cycle of water.

### Films

*Erosion.* Gateway.

How the world is changing as a result of erosion by water, wind, growing roots, and by animals' and man's activities.

*Prehistoric Times: The World Before Man.* Coronet.

Two billion years of history reviewed to give pupils a concept of the immensity of geological time.

*Water and the Soil.* Encyclopaedia Britannica Films.

# Sugar and Starch

## PURPOSE OF THE UNIT

This is a study of chemical change as applied to two of the most common basic foods. From the experiences suggested here, pupils will develop an appreciation of some of the things that go on in their own bodies—what happens to the foods they eat, what blood does, and what purpose breathing serves. They can readily apply these understandings to animals with bodies having an organization similar to ours. And their understandings are extended into the plant world—the ripening of fruits, the seasonal changes in roots and tubers, the growth of moulds.

Many of the experiences suggested for earlier grades help to prepare the way for this unit. Experiences with solutions, heat energy, and oxidation provide concepts utilized here. Work with the structure of plants and the physiology of animals makes significant contributions. In its turn, this unit helps to lay a foundation for unit ten "Plants and Light," and for "Plants That Are Not Green" in Book Six.

Health aspects of nutrition and digestion are natural components of this unit. In previous years, work with nutrition has been limited to the arbitrary selection of a proper diet. Now diet can be discussed in terms of the basic food elements.

The activities suggested are exciting to children. Individual and group work is encouraged, thus helping to develop habits of initiative, self-reliance, co-operation, and leadership. Pupils like to repeat the same experiments at home, and they may carry them further, thus meeting another goal of science education—the expansion of school work into the out-of-school lives of the pupils.

## PREPARING FOR THE UNIT

A unit of this type needs an adequate supply of materials for experiments. It is recommended that much of the experimentation be done on an individual or small group basis. This approach requires duplicate sets of materials.

Most of the required materials are commonplace and easily acquired. A few pounds of cane sugar and a box of cornstarch provide the basic chemicals. Most of the experiments can be carried out in drinking glasses or baby-food jars. The iodine may be common tincture of iodine or it can be an iodine-potassium iodide solution made especially for starch testing. Keep the iodine in bottles each of which has a medicine dropper in the cap. These bottles are inexpensive and may be purchased at drug stores. Buy several of them.

The pupils will usually bring in samples of food for testing. If they bring their lunches, test bits of their food for starch. A school cafeteria is another source of food for testing.

It is helpful to have some of the special foods mentioned in quantities large enough for the pupils to taste. Raisins, prunes, other dried fruits, apples in various stages of ripening, maple sugar and syrup, honey, brown sugar, molasses, and corn syrup are examples.

The section on the digestive system can be enriched by a chart showing the digestive system of man, and if possible, charts of the digestive systems of some common animals. These may be borrowed from general science and biology teachers. Sometimes a high school science department has a full-scale manikin with removable organs. A manikin shows the three dimensional arrangement of the digestive organs better than a chart does. Bring the manikin to the classroom or take the pupils to see the manikin.

**List of Materials**

White sugar
Brown sugar
Cornstarch
Orange
Lemon
Green and ripe apples (if possible)
Gelatin dessert
Saucepan
Paring knife
Spoons
Measuring cup
Hot-plate
Fresh fruit such as plums
Jelly glasses
Paraffin
Iodine
Droppers
Drinking glasses
Food samples for starch tests
Tin cans
Matches

## TEACHING THE UNIT

This material is ideally suited to the problem-solving approach because so many problems raised by the pupils can be solved with simple experiments or by reference to common books. A few of these problems are raised in the text, but the best problems come from the pupils themselves. Some suggested problems are "Is there sugar in pickles?", "With what part of the mouth do we taste sugar?", and "Is there starch in bread?" Before the pupils undertake each activity, be sure they have stated the problem carefully. Then, after the problem is solved, encourage them to suggest other problems. Actual problems that have grown out of the above work in classroom situations are "What else can I taste with my tongue?", "Could I preserve meat with sugar?", and "Why do green apples pucker my mouth?" The first was answered in part by experiment, the second was tried but no conclusion was drawn, and the third was taken by a committee to a biology teacher for help in finding a reference.

This unit is suggested for the fall season. Some of the fruits and vegetables, particularly the green apples, are most readily available then. In addition, the concepts developed here are utilized in the unit, "Plants and Light," which is suitable for midwinter.

The special science vocabulary in this unit consists of the words "mould" and "saliva."

### Page 71

The title page may be used to initiate a discussion of sugar as used in candy and pastries. Several worth-while problems may arise. The pupils will want to know how "milk chocolate" is made. Some of them will become interested in the story of chocolate and cocoa manufacture. Other pupils may become interested in the manufacture of chocolate creams, or caramels, or ribbon candy. They should be referred to encyclopedias, cookbooks, and to candy makers in those stores that make their own candy.

Comparable interests may result in the exploration of pastry-making.

### Page 72

Some pupils like to make lists. The problem raised on this page often results in extensive lists. Discussion will provide the first contributions, the pupils mentioning the items which they know contain sugar. Then reference to cookbooks results in many additional items.

Reference work is best organized on a small group basis, with each group taking different classifications of foods.

Pupils may like to collect pictures of foods that have sugar in them. They may prepare an exhibit of these pictures for the bulletin board.

It should be noted that confectioner's and powdered sugar are the same thing.

**Page 73**

The products of sugar cane are in such general use that they are well known to most children. However, the children may not know the origin and relationship of some of the items. Bring in as many of the products as possible, and let the pupils taste them. Certain pupils may wish to investigate sugar-making in greater detail; they should be referred to encyclopedias. Some pupils may enjoy preparing an exhibit using the sugar cane or pictures of sugar cane, together with samples of the products.

The question of other kinds of sugars may be raised. If possible, refer the pupils to a chemistry teacher. Chemistry books of an elementary nature give helpful information. The pupils will learn of such sugars as "milk sugar" and "fruit sugar." They cannot be expected to appreciate the chemical difference between these sugars, but they can learn about the origin of each.

**Pages 74–75**

Taste is not completely reliable for the detection of sugar. Often the sugar taste is masked by some stronger taste, as in the case of a lemon. In general, however, it may be said that anything that tastes sweet contains sugar. The exception is any food containing saccharine, which affects the sense of taste the same way that sugar does.

Few children realize that taste is really a combination of several senses, including the sense of smell. They become greatly interested in locating the sense of sweetness which is at the tip of the tongue. They may wish to locate some of the other specialized tastes. The sense of saltiness is easily tested with table salt. Vinegar can be used to locate the sense of sourness. Encyclopedias and biology books elaborate on the topic.

Children who have never tasted a pudding made without sugar do not really appreciate how much we have come to depend upon sugar to make our food taste good. It is difficult for us today to imagine a diet without sugar.

Gelatin is suggested for the experiment with the unsweetened pudding. Other puddings may be used. Cornstarch makes an unpalatable pudding when sugar is left out of the recipe.

### Pages 76-77

Pupils have usually had so many experiences with ripe and green fruits that they do not question the presence of sugar in the ripe fruits nor the absence of it in green fruits. A few experiments with ripening may be carried out, however. Some unripe apples and bananas may be put in a cool, but not cold, place and watched from day to day. Records of the changes may be made with coloured drawings.

Dried fruits may interest the pupils and some pupils may wish to investigate the ways the fruits are raised and processed. Among the other dried fruits that pupils may discover on the shelves of stores are apricots, peaches, dates, and figs.

### Pages 78-79

The use of sugar as a food preservative is not appreciated by most people, even by those who do home canning. The experiment suggested here demonstrates this use of sugar. Many late fall fruits such as grapes, plums, and apples may be used. If these are not available, orange marmalade may be made. Mould may form on the surface of the jam but the jam underneath does not spoil.

Few micro-organisms can survive in a thick sugar syrup, but many moulds find foods like jam an ideal medium on which to grow. Pupils should realize that moulds actually use the sugar for food. The two methods of preventing mould growth on jam shown here may be tested and compared with a jar of jam that is exposed to the air. Be sure the jars are clean and that the jam is hot when it is poured in.

### Pages 80-81

Little needs to be said about the test for starch. The techniques are simple, and the blue-black colour is easily identified. Just be sure the food to be tested is wet with water before adding the iodine.

The activity is most effective if the pupils work alone or in pairs when doing the testing. At the beginning, they may test identical samples, but later they may test the foods that they themselves have brought in. Records should be kept. The pupils may wish to make an exhibit of their records by clipping pictures of foods containing starch and mounting them on a bulletin board or in poster form.

### Pages 82-83

As is carefully explained to the pupils, the usefulness of sugar as a food is dependent upon its solubility in water. It would seem logical, therefore, that starch too is soluble. Some tests are then suggested to the pupils. The pupils are now faced with an excellent opportunity to do some scientific thinking. They will be certain that starch should dissolve. Yet their tests show otherwise, and repeated testing, which should be encouraged, does not give different results. It is true that they will be puzzled, but that is a part of science. The important problem is—should they believe their thinking or the evidence.

### Pages 84-85

We will now begin to answer some of the questions that arise when the pupils discover that starch is not soluble. It is easy to demonstrate the change of starch to sugar in ripening fruit with the iodine test. Unfortunately, in some sections of the country, green apples are not available. In apple-raising country, green apples may be found in storage where they slowly ripen through late fall and early winter. The pictures at the bottom of page 84 show the results of the test for starch in ripening apples and can be studied when an experiment is not possible.

The plants known as "biennials," a term that may be introduced to the pupils if desired, have the same life history as parsnips. The change from starch to sugar is especially noticeable in parsnips. If these vegetables are raised in the community, it should be possible to cook a few in early fall and again in early spring to note the difference in taste.

Pupils may ask how a plant can change starch to sugar. This is another one of the many questions that cannot be answered completely. We know that the plant produces chemicals known as enzymes that bring about the change, but the action of the enzymes is still a matter for speculation.

### Pages 86-87

These pages take up the problem of making starch usable in our bodies. We first consider the digestion of starch by saliva, because this process can be demonstrated. We should realize, however, that such digestion cannot be very important unless we hold each morsel of food in our mouths for a minute or so at a time.

The question of how the change is brought about cannot be answered. An enzyme in saliva changes starch to sugar, but the mechanics of the change are little understood.

The most effective demonstration of the change from starch to sugar is the digestion of an unsweetened cracker when held in the mouth. At the beginning there is little impression of sweetness. But within a minute, the tongue begins to pick up the sweetness of the newly-formed sugar.

The experiment on page 87 shows that something happens to the starch paste when it is kept in contact with saliva. It does not show that the starch paste changes to sugar. A chemical test for sugar would be needed for that proof. It might be profitable to ask a general science or biology teacher to demonstrate this test for sugar.

### Pages 88–89

The concept of starch digestion is now broadened to include the whole picture of digestion. The principal organs are mentioned and described in the diagrams. The general process of digestion and absorption is described briefly. It does not seem wise at this level to go into greater detail with an entire class. Those children who show an interest should be referred to beginning biology books.

Time can well be spent on factors that seem to encourage digestion. The mental state is one of these factors. Excitement, worry, and other tensions interfere with digestion. Pupils should be made to understand that meal-time should be one of relaxation, and that excitement should be avoided just before and just after eating. Violent physical exercise after eating heavily also seems to interfere with digestion, probably through the withdrawal of blood from the digestive organs.

The pupils should also consider the foods that seem to interfere with digestion. Fried fats, for instance, take a long time to digest. Excessive amounts of rich foods such as whipped cream and chocolate are also upsetting. Encourage the pupils to plan simple, well-balanced diets that avoid excesses of any types of food.

### Pages 90-91

That starch and sugar have energy is demonstrated here. Sugar and starch are often called the energy foods because of the large amount of readily available energy they possess. Fat contains more energy, ounce for ounce, but fat is slow to digest.

The release of the energy by sugar and starch is not unlike the release that takes place during burning. Oxygen is required, and the same chemical changes take place. The release of energy in the body is much slower, however, and high temperatures are not attained.

At this time it might be well to consider the place of starches and sugars in the whole diet. It is easy for the pupils to feel that pure starch and pure sugar will meet their needs. Point out to the pupils the necessity for many different kinds of foods in the diet, to be sure that the full requirement for minerals and vitamins is met. Show them how the energy food requirements can be met with whole-grain products, fresh fruits and vegetables, and other items that provide minerals and vitamins.

### Page 92

It was shown earlier that plants store food as starch. This page points out that animals also store food by changing unused energy foods into fat. Although children at this age are rarely affected seriously, there will come a time when many of them will have to think carefully about eating excessive amounts of energy-giving foods.

### Summary Questions

1. The pupils will probably mention sugar cane, sugar beets, and in some parts of the country they may mention maple trees. They should also mention fruits and vegetables that are noticeably sweet.

2. Starch does not dissolve and cannot enter the blood stream. Digestion changes the starch to sugar which does dissolve.

3. The answers to this question will depend upon the tests they have made. They should include potatoes and wheat because of the importance of these foods in the diet.

4. Starches and sugars are energy-giving foods. In their pure state they give nothing else.

5. The pupils should be able to describe the iodine test.

6. Plants use food stored in their roots for new growth after periods of inactivity — at the end of the winter or a dry season.

7. The pupils should be able to describe the general nature of the digestive system.

### Follow-up

Many of the concepts developed here will be utilized in unit ten "Plants and Light." There will be occasional opportunities to notice the ripening of such fruits as apples and bananas during the winter. When spring comes, observations of the new growth of plants give an opportunity to refer to the changes taking place in the food that is stored in various parts of these plants.

It is to be hoped that there will be extensive follow-up of the nutritional aspects of this unit. Pupils need guidance in selecting meals at the school cafeteria, they need to develop a consciousness of the balanced diet, and they need to learn to avoid excesses. There are many opportunities for the teacher to help the children with these problems.

When the study of alcohol and tobacco is made part of the science programme, the material of this unit provides appropriate applications. Alcohol in small quantities does no harm to the digestive system but, used extensively in large quantities, often causes damage to the lining of the stomach. Damage is also attributed to some of the chemicals in tobacco smoke that are swallowed with saliva.

More important in widespread terms is the loss of appetite after smoking. Obviously this can be serious in the case of growing boys and girls, but it may also be harmful to adults when it keeps them from eating a well-balanced diet.

The complete effects of tobacco smoke on the respiratory tract are not known. Persistent smoking often causes an irritation of the mucus membranes in the nose and throat. There is evidence that lung cancer is more prevalent among heavy smokers than among non-smokers. These facts should be given to the pupils without bias for or against smoking. Pupils will make up their own minds about smoking anyway, and they are better off having facts on which to base their decisions than having only prejudiced statements to influence them.

The effects of alcohol on the nervous system are more important and should be applied to such topics as safe driving. Economic effects of smoking and drinking can be taken up briefly, with the costs of tobacco and alcoholic drinks compared with such necessary things as bread, shoes, and meat.

## POSSIBLE LEARNINGS

Many foods contain starch and sugar.
Sugar makes most food more enjoyable.
Sugar helps to preserve some foods.
Mould uses sugar for food.
Sugar dissolves in water but starch does not.
Plants change stored starches to sugar before using them.
We change starch to sugar during digestion.
We obtain energy from starch and sugar.
Animals store excess starches and sugars as fat.

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## Books

*After-Dinner Science.* Kenneth Swezey. McGraw-Hill: Toronto, 1948 182 pages.

Simple experiments illustrated with excellent photographs.

*Experiments in Chemistry.* Nelson Beeler and Franklyn Branley. Ambassador Books: Toronto, 1952. 152 pages.

Contains good material and experiments about sugar and starch.

*Fun with Chemistry.* Mae and Ira Freeman. Random House: Toronto, 1944. 58 pages.

Simple experiments completely illustrated.

*Science Magic.* Kenneth Swezey. McGraw-Hill: Toronto, 1952. 182 pages.

More simple experiments with photographs.

## Films

*Alcohol and Tobacco: What They Do to Our Bodies.* Coronet.

This film may be used with this unit as part of a programme in education about alcohol and tobacco.

*Food That Builds Good Health.* Coronet.

Stresses the foods our bodies need.

*Learning About Our Bodies.* Coronet. Ontario Department of Education: H-64

Through the use of animation and the fluoroscope, children learn about the position and function of some of the basic organs.

*Stanley Takes a Trip.* National Film Board.

The story of a balanced diet told in cartoon form for children.

# Warm Weather Indoors

## PURPOSE OF THE UNIT

There are few sections of the country where the problems of home heating are unimportant. However, during the past few decades central heating systems have become so quietly effective that it has become easy to take them for granted, especially where natural gas is used as a fuel. In a science programme, one goal of which is the awakening of an interest in the environment, attention should be given to this important factor in our lives.

The subject matter of the unit forms an important block in the sequence dealing with heat energy in the Exploring Science Series. Experiences with heat energy in previous books have been scattered among many units—experiences with convection were given in the third-grade unit "Fire and Air," and in the unit "Controlling Fires" in this book. Experiences with radiation were given in the third-grade unit "Sunshine" and in the fourth-grade unit "A Hand Lens." Experiences with fuels were given in the first-grade unit "Signs of Winter" and in the units on fire already mentioned. The present unit draws these experiences together and gives them greater meaning. In Book Six a unit "Warm Air in Motion" will build upon and continue this work.

Some of the experiences suggested in this unit fit in other sequences, such as weather and the mechanics of gases and liquids. The experiences with insulation point out possibilities for saving fuel, and although pupils can do little about home insulation at this level, an understanding of the subject will carry over to the day when they become home owners. Thus the experiences become an important part of a realistic programme of conservation.

The unit is a practical one, based upon the study of real situations. Pupils are encouraged to observe and to question. The book gives only the most basic information. There are almost unlimited opportunities for the pupils to carry investigations further, studying heating systems in operation, questioning fathers and local heating specialists, and studying advertising pamphlets. It is highly desirable that pupils learn to look beyond the confines of the textbook to the broad world around them for their authorities.

# PREPARING FOR THE UNIT

An appropriate time to introduce this unit is during the season when heating systems are being put in operation. The occasion varies with locality, and even from year to year in the same locality. There are, of course, situations that might make it desirable to study home heating at other times of the year. Should it be possible to watch a heating system being installed, particularly in a new dwelling, the occasion may be used as an introduction to the unit. It is also possible that for excellent reasons, other units must take priority during the late autumn, thus deferring this unit until winter.

The unit is greatly enriched by arranging to have the pupils see as many types of heating systems as possible. It is possible usually to study the school heating system, and the teacher can almost always depend upon one of the custodians for help in showing details and making explanations.

It is often possible to visit heating systems in nearby buildings. Owners of homes that have outside entrances to the cellars usually do not mind if a class is taken to see the heating systems. Apartment buildings, stores, garages, and greenhouses present other possibilities.

Pamphlets and charts used to advertise heating systems often give excellent information on the details of construction and operation. These materials may be collected from local businesses dealing with home-heating equipment.

Specific materials needed for teaching the unit are few in number and easy to collect.

### List of Materials

Household thermometers (2)
Outdoor thermometer
Electric lamp and cord
Electric hot-plate
Rectangular aquarium or glass jar
Shoe boxes and tin cans
Can opener
Cardboard carton
Cellophane
Gummed tape
Red ink and ink bottle
Metal can with tight lid
Wool cloth

## TEACHING THE UNIT

The emphasis to be given in this unit depends much upon locality. There are a few places where the subject may be treated lightly, allowing more time for other units. In northern situations, however, several weeks may be given profitably to this subject if there are adequate local resources. Each teacher must decide this question in terms of the local conditions.

The order of the topics covered may be varied in many ways. Experiments may be carried out first and observations of heating systems may be made to follow. Or this order may be reversed. Fuels may be studied first instead of last as in the present organization. If hot-water heating systems are not used in a particular locality, this topic may be touched upon briefly or even omitted. The important thing is to adapt the material to fit the situation.

Only one word in this unit has been included in the special science vocabulary—"insulation."

### Page 93

The title page raises the problem about the differences between indoor and outdoor temperatures. A discussion can centre at first about adaptations to these differences, such as change of clothing, variation in activities, kinds of pets possible, kinds of plants possible. From this discussion may come the desire to start a record of indoor and outdoor temperatures. The record may be kept in chart form or it may be kept as a simple graph.

### Pages 94–95

Inexpensive hot-air heaters of the type described here are used in warmer sections of the country and in homes in other sections where central heating has not been installed. They are often used in small schools, stores, and other businesses confined to one room. They may be seen on display in hardware stores and shops dealing with home heating equipment. Because the basic principles underlying the operation of these heaters are the same as those utilized by larger hot-air systems, and because these small heaters are so easy to study, it is desirable that the pupils see one of them at first hand.

The model suggested here illustrates vividly the principle of hot-air heating. The holes in the can are most easily made with a can opener that makes a triangular opening. One of the holes at the base should be enlarged by cutting through the rim, so that the lamp cord can be passed through more easily.

### Pages 96–97

Heating systems of this type are used in increasing numbers of small homes. With a blower attached to force the air where wanted, these systems are used in homes without cellars. It should be possible to show the pupils one of these systems, either in operation or in the shop of a heating equipment dealer. If it is possible to see one of these systems being installed (in a new home) the pupils will benefit.

Pupils who have these systems at home should be encouraged to study them and report on their findings. Fathers will often help their children with their investigations. Pupils sometimes make creditable diagrams of their home heating systems, labelling the parts and describing the operation adequately. Bulletin board exhibits of such diagrams encourage other pupils to make similar studies. Parents enjoy seeing these diagrams at P.T.A. meetings and other special events.

### Pages 98-99

It is reasonably easy to show children that heated air tends to rise, but it is much more difficult to explain to them why it rises. Actually warm air does not rise by itself; it is forced upward. Air expands when it is heated, thus becoming lighter. It becomes lighter than the cool air round it. Much as a cork at the bottom of an aquarium is forced upward by the water round it, so warm air is forced upward by the cool air round it.

In setting up the box to demonstrate circulation of heated air, use a small electric lamp such as a 25-watt lamp. Any one of several ways of producing smoke can be used—smouldering paper as described, incense, or punk sticks. The smoke shows up best in a darkened room, so that there are no reflections on the cellophane. Since the circulation is best seen near at hand, allow the pupils to come close to the box to see what is happening.

### Pages 100–101

Hot-water heating systems are less common than hot-air systems, especially in small homes, because of the greater expense of installation. However, they give an even heat without the sharp fluctuations and the draughts that usually occur with hot-air systems. If there is a hot-water system that can be studied by the class, the effort will be worth while. If not, it is possible to touch on these two pages briefly and go on to other topics.

The experiment with hot water rising through cold water is striking, and the pupils will certainly like it. The greater the difference in temperature between the hot and cold water, the more effective the demonstration becomes. Ink or food dyes may be used to colour the water in the bottle. For contrast, let the children use cold, coloured liquid in a tank of warmer water.

### Pages 102–103

Radiators, despite their name, depend more upon direct heat conduction to the air than upon radiation. Radiation from the normal radiator is low and not very effective at distances over two or three feet. In anything as small as a shoe box, radiation will play a significant part in heating the air. However, at this level we are not concerned with the mechanics of heating, rather we are interested in having the pupils realize that a hot object gives off heat to the air.

The experiment at the top of page 103 shows the pupils that warm air tends to collect at the top of the box while the cool air collects at the bottom. If the thermometer faces away from the radiator, as in the diagram, air temperature rather than radiation effects are measured. Measurements of temperatures within the classroom show the same fact, especially if the air outside is cold and the heating system is operating. To obtain temperatures near the ceiling of the classroom it is not necessary to use a ladder; a thermometer may be attached to the end of a long pole, raised to the ceiling for several minutes, and then read immediately after it is lowered.

### Page 104

Steam heating is used in many schools and other large buildings because it is relatively inexpensive to install and operate. Its chief disadvantage is its fluctuation — radiators are either very hot or cool.

In more expensive systems, there are two pipes to each radiator, a large pipe bringing in steam and a small pipe taking away the condensed water. In less expensive systems, there is a single large pipe to each radiator; steam rises through the pipes and the condensed water trickles back down along the inner surfaces of the pipes.

### Page 105

If pupils live in homes where there is radiant heating, encourage them to study the principles and report on them to the class. If the system is foreign to the pupils, it may be better to touch lightly upon this topic and then move to subjects that have more significance to the pupils.

### Pages 106–107

The attention that should be given to this topic varies with the locality. If all the homes in a region are heated with natural gas, there is little advantage in emphasizing the mechanics of coal-burning and oil-burning heaters. But if many different fuels are used, some exciting studies can be carried out. The pupils may collect samples of different fuels, including different sizes and grades of coal; they may prepare exhibits of these fuels; they may investigate the sources and origins of the fuels.

The pupils may also study the different kinds of burners. Salesrooms of home-heating equipment dealers usually display coal stokers, oil and gas burners, and supplementary materials such as charts, cutaway models, and photographs. Displays of brochures advertising different makes of burners can be planned for the bulletin boards.

The school-heating plant may be studied from this viewpoint. If the fuel is coal or oil, samples may be examined. The burners may be observed in action. Problems may be discussed with the custodian.

At present electricity is not used extensively for heating homes except in regions where electrical energy is relatively inexpensive. However, one commonly sees small electric heaters being used to supplement large heaters of other kinds. In general, electricity heats coils of wires red hot and the hot wires heat nearby objects by radiation.

Sun heating has received much publicity, but this type of heating is in the experimental stage. In many solar heaters, water-filled pipes on roofs are heated during the day by sunlight, and the warm water is pumped through radiators and into insulated tanks for use at night. In other heaters, special chemicals are used in place of the water.

### Pages 108–109

The problem of insulation is an important one in homes. Insulation helps to keep heat in homes in cold weather. Insulation helps to keep heat out in hot weather thus keeping homes cool. Good insulation represents money saved, greater comfort, and a lessened drain on our natural resources of fuels.

The experiment shown on page 108 illustrates vividly the effect of insulation. Use a wrapping of wool cloth, perhaps an old coat, for effective demonstration of the principle. Encourage the pupils to try the experiment several ways, insulating first one box and then the other, using different thicknesses of cloth, and using different kinds of cloth or other wrapping. They may also try wrapping one or two bottles of hot water, taking temperatures at intervals.

Building-supply dealers often have literature advertising home insulation materials. They sometimes have interesting demonstrations showing how insulation acts. They will usually supply samples. Make use of such facilities in studying this topic.

### Pages 110-111

The presence of adequate moisture in the air is more important to our health and comfort than most people realize. These experiments will help the pupils to realize why humidity affects our comfort.

If it is possible to obtain a hygrometer of the type known as a "humiguide" the pupils can make some simple observations of the moisture content of the air.

### Page 112

Thermostats are common devices for controlling temperatures. Many homes have one or more of them. At this level it is sufficient that the pupils realize the function of thermostats, but if individual pupils wish to find out how one operates they may be referred to general science textbooks for an explanation.

#### Summary Questions

1. Pupils should list the types of heating systems common to their locality. They may add others mentioned in this text, and any other systems, such as fireplaces, with which they are acquainted.

2. Although pupils should use their own words, their explanations should include the heating of the air near the radiators, the upward rise of this newly warmed air, the warming of the cool air that replaced the warm air, and the continued nature of the circulation.

3. The pupils should describe insulating materials and their use. They may also tell about storm doors and windows, about weather stripping, and about shade trees and windbreaks.

4. Pupils should know that evaporation tends to cool things, that we sweat constantly, and that evaporation is more rapid in dry air than in moist air. The answer to the question involves these facts.

5. The answer to this question depends upon the experiences of the pupils. The accepted answer should include the fuels commonly used in the locality. Pupils may add others mentioned in this text, and others with which they are acquainted such as wood and coke.

### Follow-up

Situations often arise to permit additional work on this unit. A new house may be built near the school, making it possible to see a heating system being installed. Or an equipment dealer may put on display a new type of heater or burner.

Pupils encounter new conditions, too. A breakdown of some piece of equipment may make the services of a repair man necessary. Or a visit to another region may acquaint a pupil with some new heating device. It is often worth the time to take advantage of these unexpected situations. Class visits, visits by volunteers, individual investigations and reports, bulletin board displays of diagrams and pictures, are a few of the ways in which unexpected situations can be utilized.

## POSSIBLE LEARNINGS

Heated air tends to rise because it is pushed up by cool air.

Homes and individual rooms are often heated by the movement of warm and cool air.

Warm air weighs less than cool air.

Warm water tends to rise above cool water.

Heat from fuel can be carried to different parts of a home by air, water, and steam.

Most heat for homes comes from the burning of fuels.

Insulation is used to help keep heat in a house.

We tend to feel cooler in dry air than in moist air because of the evaporation of our sweat.

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### Books

*Thermometers, Heat and Cold.* Bertha Parker. Copp Clark: Toronto, 1942. 35 pages.

Thermometers and their uses.

### Films

*Distributing Heat Energy.* Encyclopaedia Britannica Films.

Covers the material presented in the text and includes heating devices used from colonial times to the present.

*Let's Have Fewer Colds.* Coronet.

Simple practices that can reduce substantially the number of colds we get each year.

*Our Common Fuels.* Coronet.
How man acquires and uses the common fuels he depends upon today.

# Animal Tracks and Signs

## PURPOSE OF THE UNIT

Children are usually interested in animals, and we should try to meet and extend their interests. It is the plan of this Series to suggest numerous experiences with representatives of each of the major groups of animals. Thus there are described ways of studying insects in the field and in the classroom, ways of attracting and observing birds, and ways of keeping amphibians and reptiles in the classroom.

Most wild mammals, however, are shy, many of them are nocturnal, and are difficult for children to capture for study even if we encouraged collecting. Mammal study, therefore, would be little more than a series of reading lessons were it not that mammals often leave signs of their presence. For people who know what to look for, there is much to study.

The third-grade unit "Animals in Winter" has already given some attention to this topic, particularly in describing the tracks of some common mammals. In the present unit, the material on tracks is reviewed and extended to include not only tracks but also signs of feeding and shelter construction.

It is to be hoped that through the study of animal signs pupils will find increased interest in the outdoors. There is much that is satisfying and wholesome in the study of the natural world about us. Perhaps some pupils will develop leisure-time interests that will be valuable to them for the rest of their lives.

The approach to animal study that is used here encourages pupils to develop a sympathetic understanding of the problems of living things. Attitudes such as this on the part of the general public help to ensure intelligent participation in the conservation of our wild life. Thus, this unit takes its place with others in the conservation sequence that carries through the Exploring Science Series.

## PREPARING FOR THE UNIT

Signs left by the mammals discussed in this unit are especially conspicuous during the winter months in most sections of our country. If this unit is introduced in early winter, about the time that vegetation is dead or inactive, it is possible for the pupils to follow up the study with observations extending over several months. Because one cannot be sure that a particular set of signs will be available when the unit is being taught, it is very helpful to have this follow-up period.

The more animal signs the pupils actually see in the field, the more successful a unit like this one can be. It is especially helpful, therefore, to discover beforehand some likely places where animal signs may be found. Not all of these places need be near enough for class visits; it is desirable to be able to suggest places for interested pupils to visit by themselves.

Teachers will find several sources of help in discovering sites for field observations. Older boys who hunt and trap can usually tell where they have seen indications of mammals. Adult hunters, too, give advice gladly; they can be contacted through local sportsmen's associations. Most helpful of all are individuals who make a hobby of nature study; they are enthusiastic and they have information of a type valuable to teachers.

One need not look far afield for signs of mammals. Parks, vacant lots, and even suburban gardens have many more mammals than the average person realizes. Best of all are hedgerows, abandoned fields, swampy areas, and places where people dump garbage. Only in the most densely-settled cities will there be little opportunity for field observations.

It is possible to display in the classroom some of the signs of the presence of animals. Sticks showing toothmarks, nuts and acorns that have been opened, birds' nests transformed into deer mouse nests, and plaster casts of tracks—these should become a part of the permanent teaching collection.

The only material specifically required is plaster of Paris. Plaster of Paris may be purchased in drug stores and in stores handling building supplies. However, the small cartons of plaster sold in drug stores are expensive. If possible, contact someone in a building supply store and ask for quick-setting plaster used for finishing coats in houses. A full bag is usually more than is needed, but it may be possible to buy ten or fifteen pounds from a broken bag. Be sure to get the quick-setting type.

**List of Materials**

Quick-setting plaster
Tin cans
Wire
Strips of thin cardboard
Paper clips

## TEACHING THE UNIT

The more that field observations are encouraged the more successful the unit can be. If possible, begin the unit with a field trip. A light snowfall will help to show differences in the footprints of cats, dogs, squirrels, and rabbits. A visit to a stream, pond, or marsh, where muskrats are common, will show the children the tunnels or the houses that these animals construct.

It is not necessary to take up the work of this unit in any particular sequence. It is better to take up each new animal sign as it is found.

### Page 113

This title page suggests a track story which may be seen in regions where there is at least one light snowfall once during the winter. The pupils will probably suggest that one animal is chasing another. They may realize that both animals are bounding across the field. Some pupils may recognize the left-hand set of tracks as those of a rabbit; others may recognize the right-hand tracks as those of a dog. It is not necessary, however, that they come to definite conclusions at this time. The page may be restudied later after the pupils know more about tracks.

### Page 114

Discussions of this page may well lead into the different kinds of signs that animals leave. If pupils suggest that droppings or faeces are important signs of animals, their suggestions should be recognized. The droppings of animals are among the surest signs of the presence of animals.

The discussion may also lead into the lives of people who have and who still do make their living by hunting and trapping wild animals. If so, the pupils should consider the types of animals hunted and the uses to which the animals are put. Extra readings of the lives of hunters and trappers help to enrich this study.

**Page 115**

This page mentions two of the usual differences between cat and dog tracks. It is important to realize, however, that individual animals vary in their habits much as individual people do. There are dogs that consistently put their hind feet in their front foot tracks, and there are cats that do not put their hind feet in the tracks of their front feet. The distinction based on claw marks is almost always certain, however, when the mud or snow conditions are good enough to show small details.

Pupils may remember the distinction based on the claws better if they recall how dogs and cats sound as they walk across wood floors. Cats are silent. Dogs make a clicking sound with their claws.

If a tractable dog or cat can be brought to school, press its feet on an ink pad and then on paper to get good representations of its footprints. There is nothing harmful in the ink used in stamp pads, but it may be well to wipe most of the ink from the animal's paws afterwards so that it will not lick off the ink.

**Pages 116–117–118–119**

The making of plaster casts is astonishingly easy after one or two experiences. The chief problems arise during mixing. It is best to add the plaster slowly to the water, stirring it well to avoid lumps. When the mixture pours with the consistency of pancake batter, stop adding plaster and pour the mixture immediately into the form round the track. If too much plaster is put into the mixture, a little water should hastily be added to try to thin it before the plaster sets. Should the plaster start to set before it is poured one can only clean out the can and make a new mixture.

Experience in using the proper quantities comes quickly. A No. 2 can of mixture is more than enough for a cat track or a large dog track. For larger tracks, a larger can should be used.

If it is desired to hang the casts on the wall, a loop of wire or heavy twine may be set in the wet plaster.

Duplicate casts may be made for all pupils who want them. The original is set in mud and then lifted; if the consistency of the mud is proper, a new track will show and this track may be cast. Plasticine and modelling clay serve better if these are available.

Encourage the pupils to label their casts and give the dates and localities from which they were taken.

Casts may be painted to make the tracks stand out. Black water paint works well on dry plaster. If the plaster is oily from the plasticine, an oil paint is better.

### Pages 120–121

The morning following a light, early evening snowfall is a good time to look for rabbit tracks. Rabbits are generally nocturnal, especially those that live around houses. It is difficult to follow one set of tracks for any great distance because rabbits usually circle around and move back and forth, thus making many cross trails. But by following whatever trails are found, many of the habits of the rabbits can be learned.

It is interesting to take a yardstick or a tape measure when going into the field to study rabbit tracks. The lengths of the bounds under various conditions can be studied and recorded. A rabbit hopping along at a normal, unhurried pace will make sets of tracks from two feet to six feet apart. But when really frightened, a bunny can cover twelve feet or more at a single bound.

When there is no snow, the feeding signs and the droppings are the best indications of the presence of rabbits. Rabbits are heavy feeders on blackberry canes when these are present. They also feed extensively on sumac shoots and the bark of young fruit trees, particularly apple trees. They seriously damage orchards in years when rabbits are numerous and snows are heavy.

However, rabbits are often blamed for the damage done by field mice, animals that may be far greater pests to the orchardist. The work of mice is easily identified. Mice remove the bark neatly, barely scarring the wood beneath, and these scars are obviously the work of tiny teeth. The larger teeth of rabbits break into the wood beneath, tearing up fibres and leaving a rough surface.

To help pupils to understand the pattern of rabbit tracks, it may be possible to bring a domestic rabbit into the classroom and watch it move about.

### Pages 122–123

The habits of the different species of squirrels vary a good deal, and it is difficult to generalize for the squirrels of all localities. Gray squirrels and fox squirrels are tree-living forms, chipmunks are chiefly land-living and rarely climb trees; red squirrels are intermediate, sometimes nesting in trees and sometimes nesting in holes in the ground. The tracks of squirrels vary somewhat with their way of life. Gray and fox squirrels put their front feet down side by side when they hop; chipmunks put one front foot ahead of the other; red squirrels may do either, depending upon the individual, and some individuals vary the habit as they move about. It is well to encourage children to follow tracks a bit to find out what the animal does before attempting to name it. If an animal makes tracks something like a squirrel and goes up a tree, it is probably a squirrel.

Feeding signs of red squirrels are numerous. The signs listed on page 123 are among the most common. Gray squirrels, the squirrels introduced so commonly in parks, tend to break the shell of nuts and acorns into small pieces. In winter, if there is snow, one will see where a gray squirrel digs down to a nut or acorn and then feeds on it nearby.

The nest of the red squirrel is described on page 123. More conspicuous is the summer nest of the gray squirrel, a large mass of twigs with green leaves still attached, usually bigger than a bushel basket.

### Page 124

This method of baiting animals so that their tracks can be studied can be carried out at any time of year. It may be done as a class project or individuals may try the experiment at home.

Baits that may be used are grain, crumbs, bits of bacon, raisins, pieces of fresh meat, bits of apple. Birds as well as mammals will visit the site. Unfortunately, a large animal will eat all the bait at once and leave nothing for the other animals. Frequently, too, an animal will learn to visit the site each day. (The picture on this page shows that a rat and meadow mouse have both visited the stone, arriving and leaving on the ground. However, the crow left only one set of tracks: it apparently flew off after feeding.)

### Page 125

In places where there is snow, rat tracks can be seen around almost any garbage dump and around many barns. The tracks closely resemble muskrat tracks that are also seen around dumps and in fields near the water.

White rats are albinos of the same species as house rats, and some may be brought to school for study. Their feet may be pressed on an ink pad and then on paper to study the prints.

### Pages 126–127

There are many species of mice in this country. Deer mice, more common in woodlands, and meadow mice, more common in open areas, are the most common and widely-distributed native species. House mice, introduced from Europe, are common around dwellings. In fine dust, thin layers of mud, and in suitable snow, the tracks can be identified as indicated on these pages, but identification is rarely certain because of the presence of other species with similar habits. Often it is better to call the tracks just "mouse tracks" and speculate about the species.

Deer mouse nests in old birds' nests are often seen. The mice carry fine bark, down, and other soft materials into the nest and make a snug little chamber in the centre of the mass.

Meadow mice are common almost everywhere. Many people do not suspect their presence because their signs are not conspicuous. In areas where winters are severe, one finds indications of their feeding on the bark of trees and saplings. These signs are more conspicuous after the snow melts, because the mice frequently feed in tunnels dug around the trees. The nests and the runways are also most conspicuous after the snow melts.

### Pages 128–129

People frequently confuse moles and shrews with mice, probably because of size and general appearance, but there is no relationship. Mice have large eyes and ears, their teeth are of the gnawing type, and their diet is largely vegetable matter. Shrews and moles have small almost functionless eyes, they have no external ears; their teeth are not specialized, and they are exclusively carnivorous.

Moles are known to many home owners who combat them vigorously when they get in lawns. A single mole can leave an annoying series of ridges in a lawn, not only spoiling the appearance, but also making the use of a lawn-mower difficult. Perhaps a lawn showing mole ridges is near enough for a quick visit.

Shrews are frequently called moles by people who have not studied them. Identification is easy, however. Moles have large, spade-like forefeet. Shrews have small, weak-appearing front feet. Although they are common everywhere, shrews are not often known to the average person.

### Pages 130–131

Deer tracks interest children. The footprints in mud are easy to cast because they are deep and usually clear-cut. The tracks in snow can be followed long distances without confusion. The droppings are easily distinguished. Feeding signs are not too difficult to find with a little experience.

It is improbable that the study of deer signs can be carried out as a class project. But individual pupils may follow the tracks and make casts of the tracks. Notebook records and the casts may be shown to the class as part of individual reports.

### Pages 132–133

As with deer tracks, there may be few opportunities for class study of muskrat signs. On the other hand, many pupils will have an opportunity to visit places where muskrats live. They will find numerous indications of the presence of these animals. The houses are conspicuous. The tunnels are not difficult to find. Encourage reports by individual pupils to stimulate investigation by other pupils.

### Pages 134-135

Beavers rarely live close enough to villages and cities to make quick trips possible. If a beaver colony exists within a few miles of a school, however, arrange a trip to see the work of the beavers. Perhaps a school bus can be used, or a bus can be chartered for a reasonable sum. Sometimes parents will provide their cars. At a beaver pond, signs of other animals are usually common — muskrats, deer, rabbits. The pupils can bring back sticks from which the bark has been gnawed and chips from stumps where trees have been cut down. A hand-saw will enable the pupils to bring home some of the smaller stumps. It is rare that children actually see beavers, but the signs are so numerous that all the children have an exciting time.

Children may ask why beavers build dams and houses. In the light of our present knowledge we can say only that the beavers build such elaborate structures because they cannot help themselves. They are forced by some inner compulsions to do so. There is no evidence that they plan dams and houses with future needs in mind.

None the less, dams and houses help to protect beavers from predators and from the rigours of winter. The dam provides a shallow pond in which the house is built like a castle with a big moat round it. The house is a secure refuge from most predators. The water in the pond also provides a uniform climate during the winter months. No matter how cold the air above the pond, only the surface freezes and the water beneath never drops below thirty-two degrees Fahrenheit. The beaver stores its food at the bottom of the pond where the ground does not freeze and where the food can be reached easily by swimming; thus the beaver never has to crawl on land and plough through the snow to find food.

Following a trip to a beaver pond, the class can study the effect of beavers on the countryside: the trees killed, the animals that are benefited, the effect on streams, and so on. Pupils will discover that a few beavers can bring about pronounced changes in the environment.

### Page 136

This page shows the signs left behind by some of the animals that should know better. Discussion of this page may, we hope, awaken pupils to certain responsibilities for their behaviour in some of our scenic areas. A short trip to see otherwise beautiful places may help to put the point across. Talks with people responsible for the care of parks and other public places may also be effective. Certainly, it would mean much to this country if a responsible attitude could be developed among its citizens.

### Summary Questions

1. Dog tracks show the claw marks if tracking conditions are good; cat tracks never show the claw marks. In general, cats put their hind feet in their front-foot tracks whereas most dogs do not. Pupils should be permitted to use drawings to answer this question.
2. In general, rabbits put their front feet down diagonally when they hop; squirrels usually put their front feet down side by side.
3. When green plants are scarce, rabbits feed chiefly on bark and twigs.
4. Moles have small eyes that can distinguish little, no outside ears, and large front feet. Mice have large eyes, large ears, and small front feet.
5. Moles live in tunnels in the soil, some tunnels being near the surface and other tunnels being deeper.
6. Deer footprints show two toes, or as some people say, split hooves. The hooves are sharp-pointed. The pupils should be able to draw this print.
7. The animals mentioned in this unit that make houses for the winter are beavers, muskrats, deer mice, meadow mice, and red squirrels. The pupils may be acquainted with other animals that build houses. They may wish to add the animals that dig tunnels and dens.

### Follow-up

Pupils should be encouraged to continue looking for signs of animals through the succeeding months. They may make sketches of tracks, bring in specimens, and report verbally on their discoveries.

When new and unusual tracks are discovered near the school, a short trip to see them may be profitable. If possible, these prints may be cast and the casts made part of the school collection.

Opportunities to see special films, slides, and hear talks by interested people should be considered as part of the follow-up work of this unit.

## POSSIBLE LEARNINGS

Some animals leave signs that indicate their presence.

Study of the signs of animals helps us to understand their habits.

Animals have many problems, especially during the winter months.

Tracks in mud and snow tell of the presence of certain species of animals.

Some animals build homes that are easy to identify.

Feeding signs often tell what animals are in a region and upon what they are feeding.

We can make records of tracks that help us to understand the nature of the animals that make them.

## BIBLIOGRAPHY

### Books

*Animal Homes*. George Mason. George J. McLeod: Toronto, 1947 96 pages.

An account of where there have been animals — either their homes, where they store food, or raise young.

*Animal Tracks*. George Mason. George J. McLeod: Toronto, 1945. 95 pages.

Contains good illustrations of animal tracks.

*Audubon Nature Bulletins*. Prepared and published by National Audubon Society: New York. 4 pages each.

Several of the bulletins contain background information to supplement this unit. List sent by the Society on request.

*Handbook of Nature Study*. Anna Botsford Comstock. Thomas Allen: Toronto, 1947 ed.

Valuable for general reference and as a teaching guide. An up-to-date natural history library in one volume.

*Out of Doors in Winter*. Clarence Hylander. Brett-Macmillan: Toronto, 1943. 146 pages.

Tells of winter mammals and their tracks.

**Films**

*How Animals Defend Themselves.* Young American Films.
Various defence mechanisms are shown: speed and agility, tough shells and hides, sharp claws and beaks, camouflage and mimicry.

*How Animals Eat.* Young America Films.
Illustrates food-getting adaptations of various animals.

*How Animals Move.* Young America Films.
Shows how animals have become adapted to move about in order to solve the problem of survival.

*Mammals of the Countryside.* Coronet. Ontario Department of Education: SN-87.
Some information about the common animals around us.

# The Winter Sky

## PURPOSE OF THE UNIT

The sky is a part of our immediate environment, even though its components are considered to be far away. The sky as we see it gives little indication of great distance. We may study it even as people have studied it since man began to leave records of his interests.

This unit is part of a sequence of experiences with astronomy in this Series, being preceded by the second-grade unit "Watching the Sky," the third-grade unit "Sunshine," and the fourth-grade unit "Night Comes," together with numerous experiences in other units. It is followed by the sixth-grade unit "Time and Seasons."

The study of the nighttime skies presents a real challenge to teachers, because the success of the unit depends upon the amount of independent observations carried out by the pupils. One aim of a science programme is an increased application of science to out-of-school situations. This is a unit that does more than permit such applications — it actively encourages them.

There are numerous opportunities for the pupils to practise critical thinking in this area of science. Most books say flatly that the earth is round and that motions of the stars are due to the rotation of the earth. Pupils should be urged to wonder about the truth of these statements, to investigate the facts upon which the statements are made, and to look for other explanations that might be equally valid.

There are also opportunities for the pupils to turn to books for solutions of problems that arise from observations. They develop desirable habits of work organization through this type of independent study. They learn to be critical of books as they use different sources, some of which will differ in treatment of a subject or in actual statement.

An appreciation of cause and effect relationships should develop from a study of this type. There are many superstitions in the area of astronomy. Some superstitions are based on valid cause-effect relations, some are based on chance or biased observations only. It is worth while to call attention to these superstitions, to discuss them with an open mind, and to discard those that do not seem tenable, without forgetting, however, that experiments represent the only justifiable cause for final acceptance or rejection of a superstition.

## PREPARING FOR THE UNIT

This unit requires few materials. The sky is both the laboratory and the laboratory apparatus.

To make the best use of such facilities, it is well to start preparations early in the year. The date of the fall equinox should be marked and its significance discussed. As the fall progresses, the change in the length of day and the change in the sun's path can be noted.

It is also well to begin to encourage sky observations during the clear nights of early fall. Children do not always remember to make observations on the nights suggested; they need several reminders and considerable stimulation at times. An early start ensures a better experience background, without which this or any astronomy unit becomes merely talk.

Home observations may well start with observations of the Big Dipper. Although this is a large and prominent constellation, a child may have difficulty finding it without help. An early start gives him more opportunities for getting assistance from parents and friends.

A teacher may find help from people interested in telescope-making and sky study, a hobby that is growing rapidly as evidenced by the number of its devotees. These amateur astronomers are usually delighted to share their knowledge and enthusiasm with children. They often make an annual event of an evening for the children, setting up telescopes that show the rings on Saturn, the moons of Jupiter, and the craters of the moon. By all means, try to locate some of these interested amateurs.

**List of Materials**

- Tin cans or shoe boxes
- Flashlight
- Globe
- Dark umbrella
- Gummed paper stars

## TEACHING THE UNIT

The work of the science class must be designed with the problem of encouraging nighttime observations in mind. Pupils need both stimulation and information to help them to make observations.

The construction of individual star charts and star finders helps to meet such needs. After a pupil has made a star-finding device, he is usually eager to use it. And, of course, the device helps him with his observations.

In some situations it is possible to meet the pupils once or twice for a nighttime star study class. Sometimes teachers combine these classes with a hot-dog roast, but actually the additional motivation is not necessary. Pupils are usually thrilled at the prospect of a night meeting of this type.

It is wise to arrange one of these night meetings early in the unit or even before the unit is introduced. Pupils need help in finding such constellations and other features as will be referred to in the unit. Sometimes parents attend these night meetings, and then they are able to help the pupils to make observations at home.

In organizing plans, remember that the unit is flexible. Its topics can be dealt with in any order, some may be omitted, and others may be added. It is not necessary to teach the whole unit at one time; its components may be distributed through the year, often with profit to the pupils. The important thing is to take advantage of situations as they arise and not feel bound by a formal organization.

The technical language in this unit has been kept to a minimum: "planets" and "meteors" are the two words which have been introduced.

**Page 137**

This title page can be used to introduce the concept of star patterns known technically as constellations. The pupils may be told about how we believe star study started among peoples who had to watch their flocks during long lonesome nights, and how gradually stories arose and were handed down from generation to generation of these people.

The Big Dipper is recognizable on the title page, and some of the stories attached to it may be told to the pupils. Both the Greeks and the Indians called it the Big Bear or Great Bear, but their stories were much different. The early English called it the Wagon.

Also shown on the title page are the Little Dipper and Cassiopeia. These and other star groups in this unit are shown in proper position for a December evening about 7 P.M., except where noted otherwise.

**Pages 138–139–140**

These pages tell how to find three constellations that may be seen any time of the year. Notice how important the Big Dipper is in finding the other two. Many other constellations may be found after the Big Dipper has been identified.

It is not always easy for children to find the Big Dipper for themselves. The sky is a big canopy over them, marked with thousands of stars, and there are no landmarks. If at all possible, arrange for an evening meeting of the class at which time every child should have a chance to pick out the Big Dipper for himself. Then he knows how big the star group is and how it contrasts with other star groups in terms of brilliance and general pattern.

If an evening meeting is not possible, help the children to find north. Pretend that the sun has just gone down and let them discover the northern part of the sky. If some of the pupils have compasses at home, help them to locate north with a compass.

The children often like to make individual star charts. They may paste gummed stars on sheets of blue construction paper to represent the constellations to be studied at home. They may then take the charts home to help them to find the constellations. Be sure that the constellations are oriented on the charts as the pupils will see them in the evening.

The stories connected with these three star groups may be told at this time. Individual pupils may look up these stories and relate them. Other pupils may be interested in discovering some of the known facts about the individual stars in these constellations, reporting on such things as the expected changes in the Big Dipper in the next hundred thousand years. Information of this type can be found in the numerous star books written for children. (See BIBLIOGRAPHY at end of this unit.)

**Page 141**

This tin-can star finder is easy to make and use. To help pupils to locate the positions for the nail holes, direct them to sketch on a piece of paper the constellations to be included in the finder. They need only lay this paper in place on the tin can and punch the holes through it.

If each pupil makes a finder, and if the finders are taken home on a day when the sky will probably be clear, a fairly high percentage of pupils will remember to use them. They may need a little preliminary help in using them. Darken the room and put a flashlight in the can just as the pupils will do in the evening. Then show the pupils how to locate north, in case some have not been able to find it before. Then show them the position in which to hold the can, turned so that, for winter observations, the Big Dipper is in the lower right-hand position, the "four-o'clock" position.

**Page 142**

Orion is a brilliant and spectacular winter constellation. It is one of the most readily-recognized constellations in the southern part of the sky. Pupils may make star charts and finders to help to locate it. They may also enjoy the story that is connected with it.

Interest is often high enough to expand this section of the unit to include several more constellations. Star books will give adequate help. Perseus, the Twins, and the Dragon are three constellations that are relatively easy to identify.

**Pages 143–144–145**

Orion can be used to show the apparent motion of the stars. Encourage the pupils to note other star groups and bright stars also. Try to establish the observed facts before taking up theoretical explanations. Making records helps to ensure greater participation in home observations. A record that pupils like to keep is one on which they draw the skyline as they see it from their individual homes. Each pupil may then draw in a star or constellation at intervals of an hour or more.

The theory of earth rotation has already been demonstrated in Book Four. This demonstration may be repeated with profit at this time. Place the globe in the centre of the room and place star charts on the walls about the room. Turn the globe and ask the pupils to imagine themselves on the globe looking out towards the star charts. A pupil can also be put on a swivel chair or a piano stool and rotated slowly to demonstrate why the stars would seem to move if the person looking at them were moving.

Pupils may not be able to see at first why the constellations around the North Star do not rise and set as the other constellations do. The demonstration using the umbrella helps many of them to grasp this concept. Gummed stars may be used on the umbrella instead of chalk or other marks.

If some pupil has a camera, encourage him to take a picture of the stars in motion. Instruct him to place the camera on a box with the lens toward the North Star and open the shutter for an hour or two. There should be no moon and no bright lights to shine on the camera. At the end of the period, the pupil should close the shutter and wind the film as usual. When the film is taken to be developed, it may be necessary to explain to the photographic shop what the picture is about so that a print will be made properly.

**Pages 146–147**

It is not necessary to give much attention to summer star groups beyond being sure that the pupils understand that they will see many different constellations in the summer. During the follow-up work, however, new constellations can be introduced as they become visible in early evening. (Seven Sisters also known as The Pleiades; The Northern Cross, as Cygnus; The Harp, as Lyra; The Eagle, as Aguila; The Scorpion, as Scorpio.)

**Pages 148–149**

Except for those pupils who read a great deal, the idea that the sun is another star is a novel one. Some pupils will be interested in discovering more information about it and other stars. They should report this information to the class.

Excellent photographs of the sun as taken during eclipses have been published in picture magazines, and pictures of sunspots are common. Although there is little point in dealing with these abstractions in detail, some of the pictures help to arouse interest and encourage additional reading. Such investigation should be done on a voluntary basis, however, rather than as a general assignment.

The change in the sun's path as the seasons change reviews some of the work in previous grades. The sixth-grade unit "Time and Seasons" will elaborate this topic in some detail, so it is not desirable to do so here. Call the pupils' attention to the fall equinox, the shortest day, the spring equinox, and the longest day (as near as the school year comes to it). Ask them to notice the shortening days in fall and the lengthening days in winter and spring. If, at different times of the year, the pupils will point as nearly as they can to the rising and setting points of the sun, and trace the sun's path through the sky, they will understand why the sun's path is shorter in winter than in summer. It follows a shorter arc across the sky in winter.

### Pages 150–151

The best time to introduce the topic of morning and evening stars is when one is visible. Venus can be seen as an evening star or a morning star during part of the school year. Some years it may be seen as both. Because Venus is so brilliant, it is the best one to study. The time when Venus is visible can be determined from almanacs, newspapers, and several science magazines.

After Venus has been seen by most of the pupils, study the diagrams given on these pages. Try to have the pupils understand that Venus is in the sky somewhere near the sun even in the daytime. If they have seen Venus as an evening star, for instance, they should realize that during the day Venus is following along behind the sun at about the same distance as was noted the night before. It may then be possible for them to visualize Venus circling about the sun, sometimes coming toward the earth and sometimes moving away from the earth.

Pupils may be interested in reading about other planets. Many books discuss what is known about these planets and speculate about conditions on them. Pupils often become excited about this phase of astronomy, probably because of the stimulation of certain comic strips and movies. Unfortunately, it is impossible for the pupils to distinguish between surmises and facts in much of the literature. It seems best to let this phase of the work be voluntary and individual.

### Pages 152–153

The moon makes interesting study. Its motion through the sky has the same basic explanation as the sun's motion. The phases, however, are more difficult to understand. It will be profitable to repeat the demonstration given in the third-grade unit "Sunshine."

Encourage the pupils to look at the moon through field glasses. Magnification of no more than four times is enough to make the moon seem shaped like a ball. Eight-power magnification makes some of the craters appear distinctly. If a telescope is available, the moon is an excellent subject for observation.

Photographs and drawings of the moon make good bulletin board exhibits for this phase of the work. Pupils often like to make charts and models as well. Some pupils will be interested in collecting information about the moon, but here again it is difficult to sort the facts from the fancies in much of the material written for pupils.

### Page 154

"Shooting stars" are usually seen by accident but there are a few times during the year when many may be expected. The dates of these meteor "showers" are given in star books and science magazines.

Small pieces of meteorite (for some reason, the pieces that reach the earth are called "meteorites," and the pieces that do not reach the earth are called "meteors") may be borrowed from nearby museums. There are numerous pictures of some of the larger meteorites that have been discovered.

### Summary Questions

1. The pupils may describe with diagrams how to locate the North Star by using the Pointers on the Big Dipper.
2. Orion can be seen during the winter months in the evening. It may also be seen after midnight in the fall, but evening observations are the only ones considered in this unit.
3. The North Star does not sensibly change its position through the year or from hour to hour.
4. The sun is the only star that can be seen in the daytime under normal conditions.
5. The star groups mentioned in the text are the Big and Little Dippers and Cassiopeia. Depending upon the experiences of the pupils, other constellations such as the Dragon and Cepheus may be mentioned.
6. We believe that the sun, moon, and stars seem to move because the earth rotates.
7. Venus is the planet most often seen as a morning and evening star.

### Follow-up

This is a unit that permits extensive follow-up through the remaining months of the year. New constellations will be appearing during the spring and a star study meeting in June is valuable. If the meeting is not possible, time may be taken from school work to make appropriate star charts and star finders for the summer season.

Study of the changes in the moon should be continued on an informal basis through the remainder of the year. Should an eclipse occur, the relation of the moon and the sun in an eclipse may be considered.

Seasonal variation in the sun's path should be noted from time to time and a few minutes discussion devoted to its significance each time. This subject is considered at length in Book Six of this Series.

Additional work may be done on planets as they become visible.

## POSSIBLE LEARNINGS

We believe the stars are at a great distance from the earth.

We believe that the earth and other planets move round the sun.

We believe that the moon moves round the earth.

We explain the motion of the stars, sun, and moon across the sky each day as being due to the rotation of the earth.

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### Books

*Picture Book of Astronomy.* Jerome Meyer. Ambassador Books: Toronto, 1945. 36 pages.

A direct approach with simple graphic language and coloured illustrations.

*Stars.* Herbert Zim and Robert Baker. Musson: Toronto, 1951. 157 pages.

Excellent for teachers' background and useful for able students.

*Sun, Moon and Stars.* William Skilling and Robert Richardson. McGraw-Hill: Toronto, 1946. 274 pages.

Excellent for more able students and as a teachers' reference.

*Worlds in the Sky.* Carroll and Mildred Fenton. Doubleday: Toronto, 1950. 96 pages.

Simple and enjoyable. An outstanding book in its field. Illustrated.

*Find The Constellations.* H. A. Rey. Thomas Allen: Toronto, 1954.

**Film**

*The Solar System.* Coronet.

The planets, their relative sizes and distances from the sun, together with their motions. A film useful in follow-up work in this unit.

# Electric Circuits

## PURPOSE OF THE UNIT

Electricity has become an important factor in the lives of all of us. For this reason, if for no other, it deserves consideration in a science programme that aims to acquaint pupils with their environment. There are, however, other good reasons for including this area in our programme.

The study of simple electric circuits permits the use of many activities that are exciting to children. Many of these activities call for manipulation of materials. Some activities give opportunities for pupils to use ingenuity in making variations on the original suggestions. Some develop into small group or class projects of considerable complexity. Individual and small group work can make up a large share of the work of this unit.

Thus the pupils have an opportunity to learn through their several senses. They can develop self-reliance and organizational abilities. They can develop leadership and habits of co-operation.

Through this Series runs a sequence of electricity and magnetism experiences. The present unit builds directly on the second-grade unit "Fun with a Dry Cell," and on it is built the sixth-grade unit "Electromagnets."

Safety with the use of electricity is emphasized as pupils are warned not to experiment with household electricity. They are informed about the meaning of such signs as "Danger—High Voltage" that are not taken seriously enough by some children.

## PREPARING FOR THE UNIT

This is one of the few units that requires the purchase of most of the basic materials. Dry cells, miniature sockets, miniature bulbs, and some wire are essential for the success of the unit. It is desirable that the materials be purchased in sufficient quantities so that all pupils have opportunities for individual work. For a class of thirty pupils, fifteen sets of materials give excellent results.

Dry cells represent the only items that may be considered expensive. A little planning will distribute this cost over several grades and sections of grades. To meet the needs of the Exploring Science programme, dry cells are required for the second, fifth, and sixth grades. The dry cells when carefully used will last about two years. In addition, the same cells may be used in seventh, eighth, and ninth grades when these grades are close enough to make distribution easy. Thus, the per-pupil cost can be reduced to an insignificant amount.

Lamp sockets can be purchased from science apparatus supply houses, large radio stores, and large electrical distributors. Be sure to get the size known as "miniature" because it is in this size socket that flashlight bulbs fit. Flashlight bulbs may be purchased locally. They should be rated at 2.5 volts or 3.0 volts for best service. The lamps and sockets have many uses in projects, so it is well to buy them in quantities. Cost is also lowered by quantity purchase; a box of fifty sockets costs little more than a dozen purchased separately.

The wire that is recommended for this unit is No. 24, double cotton-covered (or nylon-covered) wire. This may be purchased in large spools. Double cotton-covered wire is slightly more expensive, but it holds its insulation well and the pieces may be used again and again. The insulation of single cotton-covered wire slips off readily. Enamelled wire has an insulation that is something like a paint and the insulation tends to chip off when the wire is bent. For projects such as an electric question board, cheaper wire is satisfactory because the wire is put in place and left there.

If there is not enough money to buy materials in the quantities recommended, it is possible to teach the unit with as few as two dry cells, two lamps and sockets, and a few feet of wire. Class work must be done on a demonstration basis. The materials should then be placed where they are convenient for the pupils to do work in their free time. Unfortunately, some pupils never work with materials under these conditions, and some of the most important outcomes of a science programme do not materialize.

A few tools are needed. Slide-cutting pliers are best for cutting wire. Metal snips are needed for cutting pieces of metal for switches and can be used for cutting wire. Project-making calls for such basic tools as hammers, screwdrivers, a hand-saw, and a hand-drill with bits. Knife-blade switches are shown in some of the pictures. These switches are not expensive, but they may be omitted from the material list if the pupils make their own switches. A doorbell or buzzer and a push button are called for in one activity. Additional materials that are desirable are a clear glass bulb, some electrical fuses for study, and materials for making electric question boards, miniature houses and villages, and similar projects.

### List of Materials

Dry cells
Miniature lamp sockets
Flashlight bulbs
Insulated wire
Knife switch
Wood scraps
Round-head screws
Metal from tin cans
Panel for question board
Round-head stove bolts
Pictures for question board
Push-button switch
Electric bell or buzzer
Hammer
Drill
Nail-set
Saw
Pliers
Metal snips
Screwdrivers

## TEACHING THE UNIT

This material is organized as a "do" unit which calls for a minimum of discussion and reading. Outcomes will be evaluated in terms of skills and concrete accomplishments rather than in terms of verbalized learnings.

Try to give every pupil a chance to participate in the activities. Sometimes certain less aggressive individuals, usually girls, are crowded out of this essential participation. The advantage of having materials enough for the pupils to work in groups of two is that individual participation is encouraged.

Several projects such as electric question boards, model houses and villages with electric lights, and electrically-lighted theatres and airports are suggested. Class time must be given for planning and working on the preliminary stages of these projects, but after that, much of the work is done in the pupils' free time.

Extensive verbalization is not necessary, and many pupils will not have any desire to go into explanations of electrical phenomena. Some pupils, however, may raise such questions as, "What is electricity?" These questions are often in the same category as "What is life?" and "What is a magnet?" We know what electricity can do in many cases and we have some good theories as to its nature, but the basic question is still unanswerable. The extent to which one wants to describe the electron theory of electricity depends upon the pupil and one's own background. Remember, however, there is no shame attached to saying "I don't know."

The special science terms introduced in this unit are: "circuit," "turbines," and "generators."

**Page 155**

The title page shows a girl turning on the light in a classroom. This introduces the concept of the switch and the control of electricity. The switch in the classroom may be discussed, its function being determined by trial. How many lights are controlled by the switch? Is there more than one switch, and if so what lights are controlled by each one?

Switches in other situations may be discussed. The pupils should tell what is controlled in each case. Electrical devices such as vacuum cleaners, electric stoves, and automobile headlights may be considered, with the pupils telling where the controlling switch is located for each device.

**Pages 156–157**

These pages deal with the basic circuit and the use of a switch in the circuit as a device for completing or breaking the circuit at will. By using the knife-blade switch in the circuit, pupils can easily trace the circuit through the metal blade of the switch.

Pupils can make switches and they should be encouraged to do so, both for the better understanding of switches and for the skills with tools they develop. Two types of switches are shown: a push-button switch, and a knife-blade switch. A wood block serves as a base for each type. A piece of metal can be cut to proper shape and size with metal snips; metal from the lid of a tin can is satisfactory. Round-headed screws hold the metal strips in place and serve as binding posts. The hole in each metal strip can be made by placing it on a block of hardwood, holding a nail-set against it in the proper position, and then hitting the nail-set sharply with a hammer. A neat hole is punched through the metal.

### Pages 158–159

The concepts developed on these pages are most meaningful if based on experiences with actual materials. Perhaps an old lamp can be brought to school and taken apart. A lamp cord may be cut open to show the two wires and the surrounding insulation. A clear glass lamp bulb shows the fine wire, called the "filament," inside. If the bulb is placed in a socket and lighted, the pupils can see the wire glow. Such bulbs may be purchased in electrical stores.

### Page 160

This page shows a simple way for determining whether substances are good conductors of electricity. Substances that do not conduct enough electricity to light the lamp may be considered to be good insulators. Pupils should not be led to say that insulators conduct no electricity. Actually, every substance conducts electricity more or less, but with low voltages some are essentially non-conductors.

Encourage the pupils to test as many materials as possible. Be sure they test all the common metals so they realize that these substances are good conductors.

### Page 161

After pupils realize that all metals within their experience are good conductors, they can understand that circuits need not use wires. Any metal object can be used as a part of a circuit.

In automobiles, most of the circuits make use of the metal of the engine and frame. If possible, show the pupils some of these circuits. The storage battery, for instance, has one binding post connected to the frame of the car. There is only one wire to a spark plug, the metal of the motor serving as part of the circuit. This last can be demonstrated by taking a wire from a spark plug and holding it near any metal part while the engine is running; a spark will jump between the wire and the metal. If you have never done this yourself, ask someone to show you how to avoid being shocked.

### Pages 162–163–164–165

Pupils always seem to enjoy using an electric question board and these directions enable any pupil, no matter how inexperienced with tools, to make one.

The board may be made of one-fourth-inch plywood or of cheaper wallboard. Pupils often think of good substitutes such as the end from a plywood packing case, a fibre-board carton, or even corrugated cardboard.

The wire may be any cheap, insulated wire. However, for the pieces connected to the lamp and dry cell it is better to use wire that does not lose its insulation rapidly, such as double cotton-covered wire, nylon-covered wire, or rubber-covered wire. The bolts are round-head stove bolts that are just a little longer than the thickness of the board.

Make the holes in the board large enough to slip the bolts through without forcing. The cards can be glued in place, or held with gummed tape across the corners, or tacked fast with thumb-tacks. The lamp and dry cell may be attached to the board if desired.

There are several variations of question boards. Besides pictures, actual specimens may be wired or taped in place. A map may be used with bolts in the locations of states, cities, or countries.

After a year or so, the question board may no longer work. This is because the copper wires have oxidized, and a coating has developed between the wires and the bolts. This coating can be scraped off with a knife blade, a file, or some steel wool. However, since the value of a question board is partly in its making, an old board might better be scrapped for its parts than stored away for another class to use for their work.

### Pages 166–167

These pages describe and use the so-called "parallel circuit." It is the most useful circuit because several lamps or other appliances can be used at the same time without interfering with each other. Sometimes it is well to introduce this type of circuit by raising the problem of how to light two lamps from the same dry cell. The pupils will usually attach two wires from one lamp to the binding posts of the dry cell, and then they will attach two other wires from the remaining lamp to the dry cell. They have produced a simple parallel circuit. The next problem is to light the two lamps without using so much wire. The pupils may then be referred to the book for the solution if they do not arrive at one by themselves.

The lighting of model houses, villages, airports, and so on, appeals to children. The parallel circuit is the basic circuit to be used. Switches may be included as shown. The construction of the models should be planned and executed by the pupils as much as possible.

**Page 168**

This page describes a series circuit, one that has little use in lighting circuits because the additions of more lamps dims all of them, and because the failure of one lamp puts out all of them. However, pupils will enjoy setting up the circuit and testing it.

**Page 169**

The problem of how to light a lamp from two places may interest some pupils. The technique shown here, which uses push-button switches, is a simple one. It is not the one used in homes, as the pupils will quickly discover. In this circuit, the lamp is lighted only as long as the switch is held closed. The circuit that is used in homes makes use of switches different from the ones studied in this unit.

After the pupils have carried out the suggested activity on page 173, they might decide to substitute a bell for the lamp in this circuit, and two dry cells in series for the single cell. Then they have a circuit similar to the one in some homes where push buttons at the front and back doors ring the same bell.

**Pages 170–171**

Two ways in which short circuits can be caused are shown here. Caution the pupils carefully about permitting a short circuit to continue for any extended time. There is little resistance in a short circuit, and a large current flows. Fifteen minutes will permanently damage a dry cell. From the study, lead the children to see why it is well to remove all wires from dry cells as soon as they stop using them.

The study of fuses is important because children see from it how our homes are protected, and why directions for using fuses should be followed carefully. The temptation to replace a 15-ampere fuse with a 20-ampere fuse or with a penny, is one to be avoided. Arrange a trip to see the fuses and switch-box of a home if possible. Also have new and damaged fuses for them to examine.

**Pages 172–173**

These pages describe the use of dry cells connected in series. Notice that the other binding post of one cell is connected to the centre binding post of the other cell. It is well to supervise closely the making of series connections with dry cells. The pupils sometimes add a second wire across the remaining binding posts and thus short-circuit the dry cells.

Many pupils would like to know what would happen if three dry cells were connected in series with a lamp. For the sake of an experiment it is well to sacrifice one of the lamps. Then discourage the pupils from making a habit of connecting three cells in series. The electrical energy is three times as great as when one cell is used, and low-voltage lamps quickly burn out. However, you can buy lamps made for use with three cells: these are listed as 4.5-volt lamps or three-cell lamps.

There are a number of variations on the circuit that uses a bell and two dry cells in series. The pupils will improvise some variations. One that may be suggested to them is to put the bell and cells in a grounded circuit, using a pipe between two rooms as part of the circuit. Then the bell in one room can be sounded by pressing a push button in another room. Or the bell and dry cells may be substituted for the lamp and single cell in the circuit described on page 169. Then the bell may be sounded from two different places.

### Pages 174–175–176–177

On these pages we are developing the concept that electrical energy is not created but is transformed from some other kind of energy. This is not an easy concept in its broader aspects and much maturity is needed to grasp it, but the pupils can see specific applications such as those shown here.

In the hydro-electric plant, the energy of falling water is transformed to electrical energy. If the energy of the falling water were not used this way, it would be spent in digging away the rocks at the base of the dam. In the steam-electric plant, heat energy from the fuel is transformed to energy in the steam, and the energy in the steam is transformed to electrical energy.

Ask the pupils to tell how this energy is used after the electricity reaches our homes. They should realize that some of it is changed to light, as in electric lamps. Some energy is changed to sound, as in radios and telephones. Some is changed to heat, as in toasters. Some is used to move things, as in electric fans. They can make extensive lists of specific uses of the energy.

Electrical energy is used in a surprising number of ways in an automobile. It sets fire to the gasoline in the cylinders. It lights the numerous lamps that are used for illumination and for signalling. It turns the starter motor that cranks the car. It runs the radio, the heater, the defroster, the cigarette lighter, and sometimes the windshield wipers. It indicates the amount of gasoline in the tank.

Pupils will benefit by an opportunity to study an automobile briefly. Raise the hood of a car and let them find some of the electrical parts. Then start the car and let them see the generator being turned. Show them the ammeter on the dashboard, and explain that when it indicates "charge," electrical energy is being stored in the storage battery; when it says "discharge," electrical energy is being taken from the storage battery. Turn on the lights when the engine is not running and let them see the reading on the ammeter.

Diesel locomotives have become an important item in the Canadian scene. They owe their success to their Diesel-electric drive. Diesel engines are somewhat like gasoline engines. They burn a slightly cheaper fuel, usually an oil more like kerosene than gasoline. Because they can run at a constant speed when driving a generator, they are far more efficient than when they are used on a direct drive as they are in trucks. Thus the higher expense of building the locomotive with an electric drive is more than made up for by the cheaper cost of operation. The electric drive is also better for smooth starts, for easy stopping, and for reversing.

Many ships use an electric drive also, and some pupils may be interested in this use of electricity. Generators are driven by Diesel engines, as in the locomotives, or by steam turbines. The efficiency is greater when the Diesels or the turbines run at a constant speed, and the control of the ship is much easier.

### Page 178

Children often fail to realize just how dangerous high voltage transmission lines are. Some comparative figures may make this danger more real. Voltage is a measure of the energy of electricity. It is given in volts. The voltage of electricity from a dry cell is about 1.5 volts. Some high voltage transmission lines carry electricity of 220,000 volts, although the usual figure is 110,000 volts. Pupils should realize that they must not climb these poles, or fly kites near the wires, or approach wires that have fallen from these poles.

#### Summary Questions

1. An electric switch breaks a circuit or completes a circuit.
2. The pupils may answer this question with drawings or with the materials themselves. They should be able to use both the parallel and series connections.

3. A short circuit can be caused by letting two bare wires touch each other, or by letting a piece of metal lie across two bare parts of a circuit.

4. Fuses protect our homes by melting and breaking a circuit when too much electricity begins to move through the circuit.

5. The pupils should name metals and objects made of metal depending upon the items tested.

6. An insulator is something that does not carry electricity well enough to be used in a circuit. An insulator is often used to prevent short circuits.

### Follow-up

The pupils like to repeat many of the experiments given here. If the materials are put out occasionally, a number of the individuals will use them. They also like to play with the models they have constructed. These may be kept on display for some time. Electric question boards will be used again and again, especially if the subjects being tested are changed.

The circuits and the models constructed in this unit make good displays at science fairs, parents' nights, and similar events. Putting them in shape for display represents excellent review.

## POSSIBLE LEARNINGS

Electricity from dry cells needs a complete circuit if it is to be used.
Switches are used to make circuits and break them conveniently.
Metals carry electricity well.
Many things do not carry electricity well.
It is possible to connect lamps and other devices so that they may be used without interfering with each other.
Dry cells may be connected so that the energy of the electricity is increased.
Electrical energy is transformed from other kinds of energy.
High-voltage electricity is dangerous.

## BIBLIOGRAPHY

### Books

*Boy and a Battery.* Raymond Yates. Musson: Toronto, 1942. 120 pages.

Simple experiments with simple materials. Contains many good diagrams.

*Boy's Book of Magnetism.* Raymond Yates. Musson: Toronto, 1941. 166 pages.

Clear directions which require simple materials for experiments, tricks, and games with magnets.

*Experiments with Electricity.* Nelson Beeler and Franklyn Branley. Ambassador Books: Toronto, 1949. 145 pages.

Experiments are done with simple equipment. Contains some tricks for fun.

*First Book of Electricity.* Samuel and Beryl Epstein. Ambassador Books: Toronto, 1953.

Simple account of electrical history and basic experiments.

*First Electric Book for Boys.* Alfred Morgan. S. J. Reginald Saunders: Toronto, 1951. 263 pages.

An explanation of what electricity is, where it comes from, and what it does.

### Films

*Electricity.* Gateway.

What electricity does for us; home-made experiments with electric circuits.

*Energy in Our Rivers.* Coronet.

How man uses the energy of rivers. This includes a section on the use of hydro-electric power.

*Making of Electricity.* Encyclopaedia Britannica Films. Ontario Department of Education: SG-50.

Shows how a hand-powered generator may be constructed, and applies the same principle to electrical generation in a hydro-electric plant.

# Rainbow Colours

## PURPOSE OF THE UNIT

This is one of the units that develops the study of light in this Series. It is preceded by the first-grade units "Colours" and "Watching the Flag," by the second-grade units "Watching the Sky" and "Mirrors," by the third-grade unit "Sunshine," and by the fourth-grade units "Night Comes" and "A Hand Lens." It is followed by the sixth-grade unit "Our Eyes." Together, these units give a rich background of experiences in this important area.

The present unit calls attention to many phenomena involving coloured light: the spectrum, colour reflection, colour mixing, and colour absorption, as applied to such things as rainbows, sunsets, and protective colouration. These are phenomena in which many pupils are already interested.

Pupils are encouraged to participate actively in the first-hand experiences suggested here. Each new topic is introduced with activities that need only commonplace materials and simple techniques. Most of the suggestions may be varied endlessly, thus giving pupils opportunities to use ingenuity in developing the suggestions. Pupils are also able to use these many variations as a basis for drawing conclusions, rather than being forced to depend upon a limited number of observations.

## PREPARING FOR THE UNIT

Preparation consists chiefly of collecting various materials needed for the success of the unit. All but one of the items, the glass prism, may be acquired locally. The prism may be borrowed from a high school science teacher or it may be purchased from a scientific supply house. A glass prism is inexpensive, and it is well to buy one.

**List of Materials**

Rectangular aquarium
Pan
Small mirror
Prism
Spray gun

Light oil (kerosene or turpentine)
Soap-bubble set
Coloured cardboard
Coloured cellophane
Shoe boxes
Bottle with flat sides
Thermometers
Coffee cans with tops
Black paint
Electric lamp and cord
Electric hot-plate

## TEACHING THE UNIT

Most of the activities suggested here may be carried out as demonstrations, with the pupils acting as demonstrators. If the materials are then left in an accessible place, other pupils will be able to repeat the activities as often as they wish, thus gaining the first-hand experiences and the individual manipulation that are so desirable in a science programme.

Encourage the pupils to carry out many variations of each activity before attempting to draw conclusions. A textbook is necessarily limited, through lack of space, in the number of observations that can be suggested before conclusions are drawn. The role of the teacher is, in part, to compensate for these limitations by providing opportunities for extensive collection of data.

The only new scientific terms introduced in this unit are "infra-red" and "ultra-violet."

### Page 179

An experience similar to the one shown here makes an excellent introduction to the unit. The spectrum may be formed accidentally and then used to initiate the unit. Or the pupils may begin a series of observations of this spectrum for some time before the unit is taken up formally.

It is possible to anticipate the unit by placing an aquarium on a sunny window-sill to let the pupils discover the spectrum by themselves. If sunlight does not enter any classroom windows, the pupils may study this page and then set up the situation in another room.

Several observations will suggest themselves. What colours can be seen? What is the order of the colours? Does the band of colours move as the sun moves? Will a band of colours be formed if there is no water in the aquarium?

### Pages 180–181

These pages suggest two additional methods for forming a band of rainbow colours. Except for a possible adjustment of the angle of the mirror, and for some movement of the prism, a spectrum should be formed readily in each case. It will be noticed in the case of the mirror that light passes through a wedge of water, thus forming a type of prism made of water instead of glass.

Pupils sometimes have bits of glass that produce rainbow colours. Glass pendants from chandeliers are still seen occasionally. Glass stoppers of vinegar cruets are often made with flat, prismatic surfaces and these produce spectrums when in sunlight. Some kinds of glass jewellery give off rainbow colours, and, of course, a diamond is famous for its prismatic effect.

Out-of-doors, one will see similar effects when sunlight falls on snow and bits of ice. Stars, too, scintillate in colour when their light passes through masses of air of differing density.

### Pages 182–183

Rainbows are spectacular and usually a part of every pupil's experience background. However, the children may have only rarely noticed the specific characteristics of a rainbow. From the pictures they may determine the colours and the order of the colours. These should then be checked against the observations made of a spraybow formed by a spray gun or a lawn sprayer. Should a rainbow occur during school hours it should be observed and studied if at all possible. There is, of course, no fundamental difference between a rainbow and a spraybow.

### Pages 184–185

These pages explain in simple fashion why light passing through a prism breaks up into its component colours. No one knows for sure why the light is bent or why some colours are bent more than others, because we are not at all certain about the nature of light. Theory suggests that light travels at different speeds in glass, water, air, and other transparent substances, thus being bent when it passes from one medium to another at angles other than ninety degrees. Such explanations are better deferred to higher grades.

Some pupils may not grasp the explanation given on page 185. This is not a matter for serious concern. Pupils vary in their ability to understand abstractions of this sort. The important concept being developed is that sunlight can be broken up into several colours.

**Pages 186–187**

The production of colours in thin films represents a different type of phenomenom than the prismatic effect just studied. Instead of a simple separation of colours, there seems to be a subtraction of colours as light of one colour interferes with and neutralizes light of another colour. The pupils will see, therefore, a limited number of colours rather than the whole range.

There are many examples of this effect. After the pupils have produced an oil film on water and have observed the display of colours, they may notice a similar display in the oil film on black-top highways on rainy days. They may also see it on soft coal known as "rainbow coal" which is coated with thin films of oil.

The text mentions rainbow colours in shells, pearls and opals. Similar effects can be seen in glass and ice that is fractured in many thin cracks; the thin layers of air being responsible for the colours.

**Pages 188–189**

We are so used to colour in the world about us that we rarely question its occurrence in common objects. We think of colour as being the nature of an object rather than the result of light coming to our eyes from the object.

The demonstration suggested here shows that light is actually reflected from coloured objects. The whole appearance of a room can be altered by the light reflected from large sheets of coloured paper.

Once the pupils have grasped this concept, they may consider the colours of different objects in the room and explain why each gives to us the impression that it does.

**Pages 190–191**

A few examples of protective colouration are given on these pages. The topic may be expanded further if desirable. Usually, pupils find the topic exciting, and it becomes expanded to the proportions of a full unit. (A meadow frog is shown at the top of page 191; a weasel, at the bottom.)

Some striking examples of protective colouration are found among the insects. The pupils may collect insects from grasses and weeds by sweeping an insect net through the vegetation. They may hold an open umbrella under a bush while they dislodge insects by beating the bush with a stick. They may examine the bark of trees, decaying leaves and wood, and flowers. Besides insects, they will find spiders that have the colours of the flowers they live in, and other invertebrates such as millipedes and sow bugs.

The pupils may collect tadpoles and fish for study. Unit 14 in this book, "Life in Quiet Water," correlates with the study of protective colouration. Frogs, toads, and other small invertebrates make interesting study. Some of them, such as the wood frog, most of the tree frogs, and the lizard called the chameleon, change somewhat in colour if they are kept in the dark for an hour or so after being kept in a light place.

Mammals and birds may be seen in the field, but one cannot always be sure of finding suitable examples when they are wanted. A nearby zoo or museum that contains living and mounted specimens is helpful. Pictures are useful.

There is danger that the pupils will carry their conclusions further than the evidence justifies. We are all apt to say that the weasel has a white coat in winter so that it is not so easily seen. Actually, the weasel has a white coat in winter because this is his inheritance and there are times when a white coat is a disadvantage. It may often be that a colouration that seems in our eyes to be especially valuable to an animal is actually neither useful nor harmful to the animal.

### Pages 192–193

These experiments are somewhat academic in nature; but the principles involved are simple, and most pupils grasp them readily. The study may lead pupils to notice the effect of coloured light at sunset on the appearance of objects, and to notice how various types of artificial light change the appearance of things.

Dark green cellophane is a good green filter. Red cellophane is usually a good filter, permitting little except red light to go through. Dark blue cellophane lets some red light through along with the blue light. In each case, a doubled thickness of the cellophane gives better results. Other colours of cellophane usually permit several kinds of light to go through.

Besides cellophane, pupils may bring in bits of coloured glass. Certain bottles are made with coloured glass. Glassware is often made in colours, the red glass being an excellent red filter.

Coloured light may be produced in the classroom with coloured electric bulbs. It may also be produced by a slide projector using a doubled thickness of cellophane between two lantern slide glasses. The pupils may view objects of different colours by this coloured light.

### Pages 194-195

Pupils often ask "Why is the sky blue?" The proper response is "Is it always blue?" In the philosophy of this Series it is more important that the pupils begin to notice the variation in sky colours than it is for them to be given an answer. The problem of sky colour is an excellent one for the teacher to raise. Pupils should begin observing the sky before storms and after storms, at sunrise and at sunset, on moonlight nights and on moonless nights. They may record their observations with paintings if they wish.

The explanations given here, necessarily brief and overly simplified, may stimulate curious pupils into reading more extensively. The answers they discover may then be discussed and applied to conditions the pupils have observed.

If questions arise about the blue colour of lakes and other bodies of water, encourage the pupils to notice that the colour is largely dependent on sky colour.

### Pages 196–197–198

In recent years the kinds of radiation that lie just outside the range of human vision have become recognized as important to us. What is known as radiated heat lies just beyond the red of the spectrum and is called infra-red radiation. It is the means by which we receive most of the heat energy that comes to us from the sun. It is given off by all hot objects. Man has long made use of infra-red radiation from fireplaces and campfires. Today there are several types of radiant heating being used in homes. It should be noted, however, that many heaters called radiant heaters are actually air circulators and that the infra-red heating effect is small in these devices.

(On pages 196 and 197, black arrows represent visible light rays; the green arrows, infra-red rays.)

After pupils have carried out the experiments described on these pages they may be interested in some other devices. One common electrical heater has a polished copper reflector that reflects heat from a red-hot coil of wire. This device shows the pupils that infra-red radiation may be reflected and thus has one of the characteristics of visible light. One may also buy electric bulbs known as infra-red bulbs that are used to heat small surfaces. Some people use them for heating sore muscles. They are also used in factories to dry paint. Although such a bulb gives off a large amount of visible light, the infra-red radiation is quickly evident when it shines on one's skin.

Ultra-violet radiation, which lies beyond the violet band of the visible spectrum, causes sunburn and tanning effects. It is also known to be important in helping the body produce Vitamin D from carotin, a chemical in certain vegetables. Thus the pupils should realize that sunlight in moderate amounts is beneficial but that over-exposure can be harmful. Some homes have ultra-violet lamps that produce some of the effects of sunlight. These lamps are called "sun lamps." Caution the pupils about the dangers of looking directly at the sun or at a sun lamp, even through sun-glasses. Many sun-glasses permit ultra-violet rays to fall upon the sensitive retina of the eye and injure it.

### Summary Questions

1. The rainbow colours listed in this book are red, orange, yellow, green, blue, and violet. Some books divide the blue light into two colours—blue and indigo, giving thus a seventh colour. Actually, all the colours intergrade and many subdivisions are recognized. Books on art and the physics of colour will give interested pupils an opportunity to study this subdivision further.
2. The experiments described in this book show that a prism bends sunlight and separates its component colours, because some colours are bent more than others.
3. A true rainbow can be seen only when there is a shower and when the sun is shining behind the observer. Pupils should be able to describe the respective positions of sun, observer, and rainbow.
4. The red and blue parts of a flag reflect red and blue colours respectively. The white part reflects white light, which is a mixture of many colours in the proportions found in sunlight.
5. White paper reflects all colours. Thus, if red light shines on white paper, the red light is reflected. If a mixture of coloured lights shines on white paper, all the colours in the mixture are reflected.
6. When an animal reflects the same colour as the things round it, it is much harder to see.
7. Green light is often the only colour of light that can go through green cellophane, so that objects seen through the cellophane will show only green colours. Other colours are filtered out.

### Follow-up

The pupils should be encouraged to be watchful for indications of the separation of white light into its component colours—oil films, jewels, stars near the horizon, and snow crystals in sunlight. They may experiment with spraybows at home when they begin to water their lawns and gardens. The pupils should also watch for interesting sky colours and report on their observations. The work on protective colouration can be carried out through all the remaining months of the school year as class trips and individual trips are taken.

There will be opportunities to notice the effects of infra-red and ultra-violet radiations. The heating effect of sunlight changes as the spring advances. Trips that include experiences with very hot objects give opportunities to call attention to infra-red radiation. As spring advances, pupils go out more in the sun and evidences of sunburn, tan, and freckles begin to appear. These should be noted.

## POSSIBLE LEARNINGS

Sunlight is made up of many colours.

The colours of sunlight are sometimes separated when the light goes through glass and water.

The colours of sunlight are sometimes separated when the light goes through thin layers of oil, soap-bubble mixtures, and the like.

Many things reflect light of only one colour, or of a mixture of a few colours.

Animals are sometimes protected because they reflect the same colours as their surroundings.

Sunlight contains light that our eyes cannot see.

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*Camouflage in Nature Through Form and Color Matching.* Coronet. Ontario Department of Education: SN-21.

*Camouflage in Nature Through Pattern Matching.* Coronet. Ontario Department of Education: SN-22.

How many animals are protected from predators by their colouration and bodily shape.

*Nature of Colors.* Coronet.

The theory of colour presented in relatively simple terms.

*SN-56 How Nature Protects Animals.* Ontario Department of Education.

The adaptations of many animals in various environments as means of protection are dealt with in this film.

# Plants and Light

## PURPOSE OF THE UNIT

A knowledge of the role of green plants is essential to a real appreciation of the environment. Green plants alone are able to store the energy of sunlight in food, a process without which all other life would end. Plant reactions that enable them to make the best use of available light represent a sizable share of the commonplace phenomena that pupils encounter.

There are numerous practical aspects to the study of the activities of green plants. Garden and ornamental plants usually have rather rigid light requirements. Potato plants produce few tubers when shaded. Few lawn grasses can grow well under heavily branched trees and bushes. On the other extreme, many ferns need protection from bright sunlight and many plants flourish best in partial shade.

The work of this unit is built upon a large number of experiences with plants, sunlight, and energy as suggested in earlier books of this Series. The third-grade unit "Sunshine," the fourth-grade unit, "Water in Plants," together with the "Sugar and Starch" unit in this book, are among those that help to build the sequence of which this unit is a part. The sixth-grade unit "Plants That Are Not Green" continues the sequence.

Material included here is of help in enabling pupils to gain a better appreciation of cause-effect relationships. There is a tendency to look for causes in terms of human reactions. For instance, pupils may decide that plant leaves turn towards light because they need the light. Actually the leaves turn because of unequal growth induced by unequal lighting; the advantage to the plant is coincidental. When helping pupils to develop scientific thinking one should take advantage of opportunities like this one to make them critical of loose and unsupported statements.

## PREPARING FOR THE UNIT

Teacher preparation consists chiefly in collecting materials for experiments and in locating examples that illustrate the points covered in the unit. The first time the unit is taught, one must search for plants that show by their growth their reactions to the light supply. In succeeding years one may return to the same examples again and again.

The effect of light on tree and shrub growth can usually be illustrated as vividly in the city as in the country. Trees crowded between buildings or living in shaded gardens react much as do trees in dense forests. Massed plantings of shrubs in parks and door-yards show well the effect of competition for light. The influence of shade on low plants can be seen as well on the north side of buildings and under low trees as in a bit of country woodland. A short walk in any direction from the school turns up many illustrations to which the class can be taken or to which they may be referred.

Of the materials, the only item that may be considered essential is a house plant that has green and white variegated leaves. Certain varieties of coleus and begonia are among the several plants that have this characteristic. Several experiments call for sprouting potatoes and carrots. These are best located in late winter or early spring among vegetables that have been stored since fall. Other experiments call specifically for oat and radish seeds, but other kinds of seeds may be substituted as desired. The iodine solution for testing starch is the same as the one used in Unit Four, "Sugar and Starch."

### List of Materials

House plants
Plant pots
Oat seeds
Ice-cream containers
Shoe boxes
Sprouting potatoes and carrots
Metal cans
Glass jars
Radish seeds
Variegated house plant, white and green
Denatured alcohol
Hot-plate
Iodine solution

## TEACHING THE UNIT

Except for a short section on the formation and transformation of sugar in the leaves, the unit is based upon first-hand experiences. The more first-hand experiences that can be utilized, the sounder will be the learning process. Therefore, encourage the pupils to devise variations on the suggested experiments, trying new procedures, testing other plants. Field experiences should be as broad as time and local resources permit.

There is no reason why the order of experiences suggested here must be followed. Mushrooms may be collected and exhibited in the fall. Certain examples of weed growth are best observed in the fall, others in the spring. The important thing is to offer the experiences when conditions are most suitable. During the formal study of the unit these experiences can be organized for increased learning.

Technical words such as "photosynthesis" and "chlorophyll" have not been introduced in this unit. They are not necessary to a sound understanding of the principles involved. Pupils who do additional reading will encounter the words and sometimes may need help in understanding them. The extent to which the whole class should master the words, however, is a matter for the individual teacher's judgment.

### Page 199

The title page illustrates the unequal growth of a plant lighted from one side only. An experiment showing the same effect was suggested in the third-grade unit "Sunshine." Pupils may recall the earlier experiment and other observations they have made at home. They may also wish to repeat the experiment at this time. If so, use two plants of the same kind and of approximately the same size. Make a chalk mark on one side of each pot to identify a side and set both pots on the window sill. After a few days note the growth and turn one pot part way round. Labels on the pots may be used to explain the experiment and to record the observations.

If it is possible to exhibit a plant that has been kept in a greenhouse, the pupils will be able to contrast the effect on plant growth of overhead light and of light from the side.

### Pages 200–201

Pupils can devise several interesting variations on these experiments. They may, for instance, place a pot of oat seedlings in a box that has a hole on one side only. They may arrange the box with the potato in it, in an upright rather than a horizontal position. Encourage them to try many other species of plants. Each pupil, for instance, might test a different kind of seedling. Different groups of pupils might try different kinds of mazes for potato sprouts. The more experiences the pupils have, the more justified are the generalizations they will make.

### Pages 202–203

Trees at the edge of a woods tend to grow outward away from the woods because the outer branches grow faster and larger than the shaded ones near the woods. Sometimes these trees become markedly unequal in shape. It is not necessary to visit a large woods to see this effect. Even a small grove of densely-growing trees will serve as well. To a lesser extent, one may see the effect in trees and shrubs that have been planted too close to buildings, but not all species are equally affected.

The growth of a vine on a building makes interesting study. Some species cover the wall so effectively that the wall cannot be seen through the leaves and yet the leaves barely overlap each other. If the pupils try to sketch a small section of the vine they will see how effective this manner of growth is.

### Pages 204–205

Plants growing in darkness do not develop the green colouring that we associate with most plants. New grass under a board has a yellow colour. Potato sprouts in a dark cellar are a ghostly white. A few hours of sunlight, however, is all that is needed to produce the green colour.

It is suggested that carrots be used in the experiment on page 204. Other plants that may be used are onions, beets, parsnips, potatoes, and sweet potatoes. Many wild plants such as wild carrots and squirrels' corn can be used. Choose specimens that have started to grow. In both this and the experiments with seedlings, give the plants some light after a few days and note how rapidly the green colour develops.

### Pages 206–207

Experiments on previous pages have established the understanding that plants can develop a green colour only in the presence of light. It is possible for the pupils to view some of this green colouring matter by crushing a leaf between two pieces of white paper. It is also possible to extract some of this green colouring matter, known technically as "chlorophyll," by dissolving it in alcohol. A leaf is first boiled to break down the cell walls and then it is put in a small amount of alcohol. Denatured alcohol, available at drug stores, may be used. To give a deep green colour to a drinking glass of alcohol it will be necessary to use a number of leaves. The solution may then be bottled and labelled.

Several toothpastes and certain pet foods contain chlorophyll. The chlorophyll is extracted from such green plants as alfalfa. The chlorophyll is supposed to act as a deodorant although its effectiveness is disputed.

The pupils may be interested in carrying their study of the green colouring matter further. Where, for instance, is it found in plants besides in the leaves? Is it found in stems and, if so, is it in the outer part, in the centre, or in both? Is it found in the stems of woody plants and, if so, where? Will the root of a plant turn green when exposed to the light? If a leaf is picked will it lose its green colouring faster if put in sunlight or kept in darkness? Will the leaf lose its colouring faster if kept damp or pressed between dry blotters?

The children need a bicoloured plant such as coleus or begonia for the experiment. Be sure that the plant has been exposed to sunlight for several hours previous to the experiment to ensure the presence of starch. Cold alcohol does not dissolve chlorophyll rapidly and it may be necessary to reboil the leaf two or three times before the leaf is bleached. It is possible to warm the alcohol by setting a metal container of it in a pan of hot water. However, alcohol is inflammable and should be kept away from an open flame. It should not be heated directly over an electric hot-plate lest it boil over.

The iodine test of a bicoloured leaf of this type will show that starch occurs in the region that was originally green and not in the white regions. The pupils may wish to experiment with leaves of red and green colour but they may not have significant results. The red pigment is often present with the green colouring matter, masking it because of its greater intensity. The whole leaf, in such a case, shows the presence of starch.

### Pages 208–209

The experiment on this page demonstrates the necessity for light in the production of carbohydrates. The children may wish to try variations on the experiment, perhaps enclosing one leaf—or part of one—in opaque paper or foil.

It seems desirable to avoid a misunderstanding that has arisen about the presence of starch in the leaves of plants. Sugar is the direct product of the food-making process, but sugar and starch seem to be readily convertible one to the other. Sugar that accumulates during the day is transformed to starch. During hours of darkness, this starch reconverts to sugar, dissolves, and is slowly moved to other parts of the plant.

The role of the green colouring matter, chlorophyll, in the sugar-making process is not understood despite the great amount of research that has been applied to the problem. It seems worth while to point out to pupils that this is one of the common things around us that needs investigation.

**Pages 210–211**

These information pages explain what happens to the food that is prepared in the leaves on sunny days. Some is used immediately for growth and the processes of living. Some is converted into building materials such as the woody fibres in plants and the proteins that are in the living matter of the cells. Much of the food is stored for later use. Perennials and biennials store food for rapid spring growth. Food is stored in seeds and is used by the developing seedlings. Sometimes food in fruits serves to attract animals that distribute the seeds.

A number of plants convert sugar and starch into oil. The pupils can discover the presence of this oil by crushing a bit of the plant between pieces of paper and then warming the paper. The paper shows an oily spot. The "meat" of peanuts and many other nuts is usually rich in oil.

Some pupils may want to study further the various uses we make of seeds. They can prepare exhibits of products derived from corn and peanuts, showing pictures and actual specimens of the products.

**Pages 212–213**

These pages suggest some interesting field work. In studying the shadow of a tree, the pupils may outline the shadow with a long piece of twine and mark the sunny spots with bits of paper roughly torn to shape and pinned to the ground. With the ordinary mature shade tree, little sunlight passes through.

They may also study the leaf arrangement of many kinds of low plants. They will discover many interesting variations and they will not be able to account for all of them, but often the advantage to a plant can be seen readily. In lawns, they will see how quickly a plant with a rosette of broad leaves kills the grass round it.

**Pages 214–215**

The effect of light on tree growth is often striking. It is important, too, especially in the case of forestry management. This is because the best lumber comes from tall, straight, limb-free tree trunks.

It will be easy for the pupils to study a tree that grows out in the open, either in a field, a door-yard, or a park. They will note the large limbs growing near the bottom of a tree, limbs that would interefere with the use of the tree for lumber.

The pupils may decide to make a study of typical tree shapes. The vase shape of the Canadian elm is distinctive, especially when the leaves are off. There may be other trees in the neighbourhood that will repay study. Sketches and photographs of these trees make good exhibits.

Except in rural areas, it is usually more difficult to study the shape of trees in a thick woods. However, a small plot of land that has grown up thickly with saplings will show the same effect, on a miniature scale. Point out to the children the dead lower branches and have them compare the living lower branches with similar branches on saplings near the edge of the thicket. If the owner of the property gives permission, cut a sapling from the middle of the thicket and another from the edge to compare the general growth.

**Pages 216-217**

The concepts developed on these pages should present no particular difficulties after the work that has been done on the need for light in food making. There may be little opportunity for field observation or for experiment to substantiate this material, unless it is possible to set up a small test plot, either in a school garden or in a nearby private garden. When a test plot is possible, the results are striking, particularly in showing the effects of weeds on the growth of garden plants.

Pupils may wonder at first why garden plants grown in the shade are often much larger than the same plants grown in full sunshine. If they have opportunities to compare the plants, they will see that the former plants are weaker and the green colour is paler. If the experiment can be conducted long enough, they will see that the shaded plants do not produce flowers, fruit, or roots that compare favourably with those on garden plants grown in sunshine.

**Pages 218–219**

A few minutes spent investigating shaded places around a school usually reveals plants that have low light demands. Some of these plants also do well in full sunlight, but many cannot withstand the heat of full sunlight. It is interesting to select two areas—say two sections of a lawn—one shaded, one in full sun, and compare the plants growing in each. It is not necessary that all the plants be identified although it is helpful if they can be.

The problem of plants for shaded flower beds is of interest in communities where home gardening interests the residents. A trip to see successful flower beds may be arranged. If interest is high enough, some pupils may like to study catalogues and plan shaded gardens.

If possible, take the class to a woodland to see the plants growing there. The most interesting time is in the spring when most of the flowering plants are in bloom. It may be helpful to invite someone who knows the common wild flowers to go along. Many gardeners make a specialty of wild flowers, and if a trip to a woods is not possible, a trip to a wild flower garden might be arranged.

Most house plants have low light demands and some thrive in the darkest corner of a north-facing room. For experiments with some of these plants, use slips of Philodendron or Wandering Jew, which do not need to be rooted and which require little light.

### Pages 220–221

The amount of work that can be done on water plants depends upon local resources. If there is a pond or sluggish stream nearby, a number of the water plants may be collected and, if possible, identified by name. When there is no such source of water plants, aquarium plants may be studied. It is possible to carry out experiments with submerged plants, keeping some in bright light and some in complete shade. It is not well, however, to let direct sunlight fall on the water because this heats the water and drives out the oxygen dissolved in the water.

Microscopic plants will grow readily in water that is in direct sunlight. Tap water is usually chlorinated, so use water from ponds, streams, rain barrels, or the like. Then scrape a few plants from the inside of a bird bath, an aquarium that is coated with green "scum," a stone from a pool, or some similar source. Put the plants in the water. In a short time, the water in the container will be almost opaque because of the microscopic life. A similar container, kept in a shaded place, will have little or no microscopic growth.

If a compound microscope is available, let the pupils look at some of these microscopic plants.

**Page 222**

The best time to find a wide variety of non-green plants is in late summer and early fall but some specimens can be found at any time of year. Even in the coldest weather, one can find bracket fungi and similar forms growing on dead and living trees. The external parts of fungi are usually the "fruiting" parts that produce spores; the true body of such a fungus can be seen by tearing away the rotting wood or separating layers of dead leaves. It appears as a mass of shining threads.

Indian Pipe and Beechdrops are seed-bearing plants that do not have the ability to make their own food. There are a few other seed-bearing plants that have also lost this ability.

### Summary Questions

1. Green plants use the energy in light to make their food.
2. A green plant kept in darkness stops developing green colour, and after it has used up its food it dies.
3. Green plants use their food for energy and for growth.
4. Green plants cannot live at the bottom of a deep lake because there is too little light there.
5. Trees in a forest receive light only from the top and therefore the top of the tree grows fastest. Trees in a field receive light from all directions and therefore become thick and bushy as well as tall.
6. Plants that are never green get their food from living plants or from dead plants.
7. Green plants are the source of food for all other living things.

## Follow-up

Some of the experiments suggested here require several weeks before results are evident. Many of the experiments will suggest related experiments that the pupils would like to carry out: experiments that do not require much additional effort beyond a few minutes of care and some brief observations daily, but which extend the needed time by several more weeks.

Trips taken later in the season will bring the children in contact with additional situations discussed in this unit, such as plants affected by light coming from one direction only, trees in fields and woods, plants that have low light requirements, competition between weeds and garden plants. In each case, a brief mention of the situation calls it to the attention of the pupils and serves as excellent review and follow-up.

Some pupils take many trips by themselves and with their parents. Encourage them to bring in and display samples of plant types referred to in this unit, such as non-green plants, water plants, and woodland plants.

## POSSIBLE LEARNINGS

Many plants are green because of a green colouring matter in their leaves and stems.
Green plants can make such foods as sugar and starch.
Light and green colouring matter are needed in making foods.
Many plants store food for use in later growth.
Plants differ in the amount of light they need for good growth.
Some plants do not make their own food but use food already prepared by green plants.

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Valuable for general reference and as a teaching guide. An up-to-date natural history library in one volume.

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A book of simple experiments with plants.

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A first book about trees.

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The process of food making seen in animation.

*Wild Flowers*. Encyclopaedia Britannica Films.

Shows woodland, meadow, and field flowers by time-lapse photography.

# Lifting Things

## PURPOSE OF THE UNIT

One of the outstanding achievements of modern times has been the development of machines that relieve man from the burden of lifting heavy loads. In factories, there are ingenious devices that make it unnecessary for workers to pick up heavy objects. Extensive digging with pick and shovel is practically unheard of today. Farm work has been revolutionized by machines that handle hay, grain, milk, and other products that once drained the muscular energy of the farmer. Lifting machines have become a part of our culture.

Throughout the Exploring Science Series there is a sequence that points out the importance of these machines in our lives. This unit is part of that sequence. It builds upon such units as the second-grade unit "Moving Things More Easily," on the fourth-grade unit "Balancing Forces," and on experiences suggested in other units. In turn, it serves as a foundation for the sixth-grade unit "Making Work Easier."

As with all mechanics units, it is essential that the pupils use their muscular senses in studying the principles of machines. Experiences with the windlass and the pulley are suggested. Pupils should develop the habit of using all their senses in learning about the things around them.

Model making is suggested in several places in the unit. Model making has several values beyond that of clarifying certain scientific principles. Models challenge the imagination and the ingenuity of pupils. They develop skills with tools and with handling materials. They satisfy a creative urge present in most children, and they provide an outlet for self-expression for many pupils.

## PREPARING FOR THE UNIT

Most of the preparation for this unit is divided between two sets of needs, opportunities to see lifting machines in operation, and opportunities for working with simple machines and models.

Examples of machines used to lift heavy loads can be found in many places. Many of these are located permanently or semi-permanently and can be visited year after year once they have been located. Look for elevators in tall buildings, large stores, and factories. Open freight elevators are easier to study than most passenger elevators. You will find many types of derricks and cranes in factories, in railroad loading yards, and at docks. Loaders can be found on farms, in grain elevators, feed mills, coal loading yards, and in sand-grading devices. Power shovels can be found in gravel pits and clay pits.

Sometimes there is a construction project near the school. Then the pupils can see many types of lifting machines in action. Derricks are used during the construction of large buildings and bridges. Power shovels and other types of excavating machinery are used in digging foundations, deepening streets, levelling land, and putting in pipelines or sewer pipes. A class may make intensive studies of one of these construction projects.

The pupils will need a few simple tools and materials for their experiments and their model making. Pulleys can be purchased at hardware stores and variety stores. Such pulleys are inexpensive and more satisfactory than pupil-made pulleys for experiments with heavy weights.

Certain mechanical construction kits designed for boys are excellent for schools and their cost is less than the cost of three or four good books. Many pupils are benefited more by the purchase of one of these kits than they would be by the purchase of any number of books. The more expensive kits include pulleys, gears, cranks, and electric motors.

### List of Materials

Pulleys
Pencil sharpener
String
Tin cans
Wire
Sand
Spools
Board
Small cardboard boxes
Nails
Hammers
Coping saw
Cross-cut saw
Hand drill with bits
Screwdrivers
Metal snips
Wire coat-hangers
Wire-cutting pliers

Sticks
Scraps of soft wood
Mechanical construction kits
Screws
Screw eyes

## TEACHING THE UNIT

The material of the unit is flexible. One may use it in the order given here or one may rearrange the topics as desired. This makes it possible to utilize local situations to best advantage. A construction project near the school may make it desirable to begin with the section on excavating machinery. Or, if a trip to see a derrick operating is possible, the study of derricks should open the unit.

Many girls may lack interest in this material. They have, or seem to have, as much manipulative ability as boys, but social pressures act to keep them from developing mechanical interests. In carefully handled situations, or when segregated from boys, girls often become very excited about such things as pulleys, and they carry out construction activities with high interest and good success.

The answer seems to be to treat the girls just the same as the boys, giving them the same opportunities and preventing the boys from dominating the activities. Some of the girls may need special encouragement, they may need to be shielded from the ridicule of the boys, and they will need generous praise for their contributions. Some boys may also need this extra attention.

### Page 223

The title page may be used in a general introduction to the unit or it may be deferred until derricks are studied. When used as an introduction, the details of the operation of a derrick are less important than a consideration of how it helps us. The discussion might well centre about the number of men who would be needed to lift the same loads and how slowly they would have to move. Or the discussion could anticipate a question on page 224 and result in the making of a list of things that must be lifted to higher levels.

### Pages 224–225–226–227

A hand-operated windlass is truly spectacular in a kinesthetic sense. If one can be located, and if the pupils can operate it, they will be deeply impressed by the ease with which they can lift a heavy load. If such a windlass cannot be found, it would be worth the effort to find some shop teacher or science teacher who would co-operate in constructing one something like the windlass once used to draw water from open wells in the days before pumps.

The model made with a pencil sharpener is an effective teaching device on a small scale. It will raise a can of sand with surprisingly little effort. To keep the string from slipping on the end of the sharpener, wrap a number of turns very tightly on the metal, and have the string long enough so that these first turns are not disturbed.

Interest the children in looking for windlasses and reporting on them to the class. They may draw pictures to show how the windlasses were used. They should also tell what they saw being lifted by the windlasses.

They may look for pictures of windlasses. Advertisements and magazine articles describing construction projects show machinery that makes use of windlasses.

The applications described on pages 226 and 227 may encourage some of the pupils to do individual research in encyclopedias concerning sailing vessels, mines, quarries, steamships, and other places where windlasses are used. These pupils may then report to the class on their findings.

### Pages 228–229

The study of an elevator in a nearby building can be a very exciting project for the children. After making proper arrangements with the owners or custodians, let the children look into the bottom of an elevator shaft, view the hoisting machinery at the top, and ride in the elevator to see how it is controlled. Sometimes, a custodian or engineer can tell the children about the safety devices used on the elevator.

Following the trip, the pupils may make drawings that show the fundamentals of the elevator studied. Some pupils may attempt to make a model.

(The label "Electric wires" on page 229 indicates—apparently—only one wire. Actually, there are several wires inside this cable.)

### Pages 230–231

This model elevator is simple enough for any pupil to make. It lacks some of the features of a real elevator but it illustrates the use of the windlass and the counterweight. It may be necessary to explain the counterweight to the pupils, mentioning that it has about the same weight as the car, and showing how this makes it easier to raise the car and to keep it from descending too fast.

The advantage of presenting a design as simple as the one described here is that it permits pupils with ingenuity to modify the design and improve on it. For instance, in one school pupils made a four-storey apartment house from an orange crate, adding two more floors by nailing in the ends taken from another crate. They installed the model elevator on one side of the apartment house, cutting doors on each level. The spools were nailed in position on the side of the crate and the open side of the car faced the doors.

**Pages 232–233**

The use of buckets on a belt to raise loose materials is more common than many people realize. Portable "loaders" are coming into increasing use. They are used in many places where trucks are loaded with soil, coal, and similar materials. One man with a loader can do the work of ten or twelve men working at top speed. Look for them in coal-yards, in places where soil, sand, gravel, crushed stone, and cinders are handled. Many highway departments use them to load their trucks. In northern cities snow loaders operate on this principle. Certain types of hay loaders work on the same principle.

Belts with buckets are used in permanent installations. Besides grain elevators, one may find them in feed mills, coal storage bins, sand and gravel storage bins, and many factories. A trip to one of these buildings may be possible.

There are toys that use the belt and bucket principle to raise sand. One of these toys will be an asset to the teaching collection. Sometimes the pupils will donate one or more of them. These toys should be put where the pupils can operate them.

**Pages 234–235–236–237**

The use of a single fixed pulley to lift objects is commonplace, and most pupils will have seen many applications of it. The single pulley as usually used gives no mechanical advantage other than making it possible to pull down while raising something, or of having the machinery that does the pulling near the ground instead of on a high framework.

Pupils will see applications of the single pulley on a flagpole, on windows that have counterbalance weights, and on a hayfork of the type described on page 235. They may have opportunities to see other applications.

For experiments, use awning pulleys of the type sold in hardware stores and variety stores. It is well to buy several of these in different sizes, because pupils may want to use them in their model-making.

The directions on page 234 show how to make a simple pulley. This pulley is easy to make but it will not support a heavy load. However, pupils gain satisfaction from making things. Some pupils may make more realistic models.

Perhaps it will be possible to visit a barn where there is a hayfork and watch a demonstration of its action. A demonstration is the only effective way of showing how it operates.

Page 236 describes the use of a pulley to reduce the force needed to raise a load. We can see that the two ends of the string are supporting the load. Thus the person needs to pull upward with a force equal to half the weight of the load. If a heavy weight is used, the experience can be surprising to those who have never lifted a weight this way.

The next page shows an application of the principle. The travelling crane has four pulleys in each "block." At this time, we will not study how much compound pulleys reduce the force needed to lift a load beyond realizing that the force is lessened. More attention is given to this subject in *Exploring Science Six*, "Making Work Easier."

Pupils may be able to find several applications of pulleys used in this fashion. Derricks, power shovels, and other lifting devices that utilize cables usually use compound pulleys.

### Pages 238–239

Derricks are in constant use in construction projects. Most pupils have seen one but they may not have seen it operate. Try to arrange a trip to see a derrick in action if at all possible. Derrick operators become adept at their trade and it is fascinating to see them manipulate a device that one would think is clumsy but which is actually very graceful.

Basically, a derrick has two sections that are controllable. The "hook" may be raised or lowered to pick up or lower a load into place. The boom may also be raised or lowered, thus changing the distance from the foot of the derrick to the place where the hook comes down to the ground. In addition to these two controls, a derrick can usually be turned, thus adding to the area where the load can be picked up or dropped.

### Pages 240–241

The use of triangles for giving rigidity to a structure is a basic practice in engineering. Examples will be found everywhere. Pupils may first construct their own triangles and rectangles for experimentation, using strips of thin wood held together with tacks, or using strips of heavy cardboard held together with paper fasteners. Then they should begin looking for applications of triangles in structures about them. Triangles may be found in shelf supports and in complex machinery. If a house is being built nearby, the pupils will see diagonal braces being used to support the walls of the house. The roof is often in the shape of a triangle, with strong timbers forming the base of the triangle. Fences are usually braced at the ends with diagonal pieces of wood. Bridges, derricks, towers, and similar structures are but a few of the other places where one may see examples of triangles used for support.

**Pages 242–243**

Models help immeasurably in appreciating how derricks work. The models described here need little explanation. The second model is made with materials from a construction kit of the Tinker Toy type. The first model is made with odds and ends of wood, strings, and hardware.

The mast and boom of the first model may be made of round or square sticks. The hole for the bolt must be bored with a small drill. The headless nail used at the bottom of the mast is a brad or finishing nail which has a small head. It may also be a common nail from which the head has been clipped by a cold chisel or metal snips.

Ingenious pupils will improve upon this design in many ways. They may also wish to make models of other types of derricks. Encourage them as much as possible: they are learning many important things.

Kits used for making mechanical models will be especially useful in teaching this unit. If the school does not have one and one cannot be be purchased, some of the pupils may be able to bring one or more kits to school. These kits contain directions for making excellent working models.

**Pages 244–245**

Try to take the pupils to see different types of soil excavation machinery in operation. Where houses with cellars are being built, power shovels are usually used. Various types of trench excavators are used to dig ditches for water, gas, and sewer pipes to new houses. Almost all construction projects use soil-digging machinery at some stage of the operation.

Some pupils may have toys that are models of power shovels, clamshell diggers and other common types. They may be willing to bring these to school and demonstrate them. Some pupils may donate these toys to the teaching collection.

Encourage pupils to undertake model construction. Their models may not be effective soil diggers but they will illustrate the general principles of the machines.

### Page 246

The car lift shown here is part of everyone's experience but few people understand its operation. This diagram will help, and a trip to see one operate will usually answer any remaining questions. A barber's chair operates on somewhat the same principle. A foot-operated pump forces oil into a cylinder and this raises the chair.

### Summary Questions

1. A windlass winds up a cable or rope, thus lifting something or exerting a pull. The windlass also unwinds the rope or cable, thus permitting the object to go down again.
2. The pupils will probably describe the belt-and-bucket type of loader. Some may mention the power shovel.
3. The car of an elevator is raised by a windlass that winds up a cable attached to a car. A counterweight, or balance weight, helps the windlass.
4. The pupils should describe the compound pulley pictured on page 237 or any other compound pulley within their experience. Permit them to use diagrams in making their answers.
5. Besides the applications of derricks given in this unit they should add the applications they have seen or read about.
6. This request calls for a description of some of the excavation machinery described here or seen in the neighbourhood. Several pupils may be asked to describe individual devices.
7. Pulleys are shown being used in a few ways in this unit. The pupils should add other instances from their own experience.

### Follow-up

As the months progress, pupils will have opportunities to see new types of lifting machinery or will see familiar machines at new types of work. Encourage them to report on these experiences and arrange trips for the whole class when something unusual presents itself. Additional pictures may appear in magazines. These should be clipped and posted on the bulletin board.

A unit of this type can well be followed by an exhibit of models, pictures, and diagrams. Such an exhibit is very effective for a parent's night or a science show. The models may include toys, models made from simple materials, and models made from kits. As many exhibits as possible should be working models, and the pupils should be present to operate them if the exhibit is prepared for visitors. The exhibit need not be confined to just the machines studied in this unit but may be broadened to include many interests of the children.

### POSSIBLE LEARNINGS

Certain machines help us to lift heavy things.
Some machines do the work of many men.
Some complicated machines use several simple machines, like the pulley and the windlass, acting together.

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**Film**

*Machines Do Work.* Young America Films.
Develops an understanding of simple machines. Shows how machines make our everyday life easier.

## Boats

### PURPOSE OF THE UNIT

The study of mechanics should be an important part of every science programme, dealing as it does with principles that govern so many of our activities. One subdivision of mechanics is the study of gases and liquids. This unit is part of a sequence in this Series of activities in this important area.

The study of buoyant forces, which makes up most of this unit, has many important applications. Some of these applications make the things pupils see about them more meaningful. Some have immediate practical application, especially to beginning and inexperienced swimmers who should understand the principles of buoyancy.

Safety aspects of boating are considered in this unit. A large number of children of this age are already using boats. Others almost certainly will be at some time in the future. A little attention to boating safety at this time may save lives.

This is a discovery unit which permits the children to learn through experiments, demonstrations, and other first-hand observations. The background so established can be expanded almost indefinitely by reading along lines determined by the individual interests of the children.

Creative work is encouraged. Children who like to build things are given opportunities for self-expression. At the same time, children who like to report on their readings or other research, and those who like to make diagrams and drawings, have ample opportunities for expressing themselves.

## PREPARING FOR THE UNIT

This is essentially a "do" unit and it is well to assemble materials ahead of time so that the activities are not held up because certain critical items are missing. Most of the materials are commonplace and easily acquired, in keeping with the philosophy of this Series.

For demonstrations of buoyancy, a large glass vessel is especially useful. A rectangular glass aquarium is most satisfactory, but a gallon jar can be used. Some form of weighing device is needed. A spring platform balance of the household type is suitable and may be borrowed more easily than other types. The model submarine needs materials best borrowed from a junior or senior high school science teacher—a bottle with a two-hole stopper, two short lengths of glass tubing, and a length of rubber tubing.

For making model boats, some tools are needed. These include a cross-cut saw, a coping saw, metal snips, hammer, and a jack-knife. Small items such as nails, tacks, and screw eyes should be available.

Pupils sometimes have model boats that they will bring in for display and for experiments. Model rowboats can be loaded with different weights to show the change in floating level. Model sailboats show the action of sails and rudders. Model motorboats show the action of propellers and rudders. Occasionally a working model of a submarine will be brought in.

Sometimes there is a small body of water near the school. The sailing of model boats in such a pool is far more satisfactory than anything that can be done in the school. It may be necessary to obtain permission to use the pool. A race between pupil-made sailboats may be planned.

If there are large bodies of water near the school—ponds, lakes, or rivers—take the children to see boats that are drawn out of the water for the winter or for repairs. Then the children can see the rudders and the propellers.

A trip to visit an ocean-going vessel or an inland-water ship is valuable. The pupils are interested not only in the ship itself, but in the cargo, the crew, the ports usually visited, and the history of the ship. English school children sometimes "adopt" a ship, keeping in touch with the crew by letters and postal cards, and following the sailing routes on their maps.

**List of Materials**

Rectangular aquarium or large glass jar
Rubber balloons
Paper cups
Corks
Small bottles with corks
Drinking glasses
Tin cans, various sizes
Scales
Sand
String
Nails
Bottle with two-hole stopper
Short lengths of glass tubing
Rubber tubing
Medicine droppers
Egg
Salt
Scraps of lumber
Screw eyes
Wire
Metal from tin cans
Rubber bands
Faucet washers
Hammer
Coping saw
Cross-cut saw
Jack-knife
Metal snips
Tacks

## TEACHING THE UNIT

If the children can be taken outdoors to sail model boats, and to visit real boats, this unit is best taught during seasons of warm weather. However, if conditions require that the unit be taught indoors in its entirety, the work may be carried out at any season.

Some teachers like to combine this unit with a transportation unit in social studies. There are numerous opportunities for enriching both units by this correlation.

Many of the activities suggested are best carried out on a demonstration basis. However, we want all children to learn through their muscular senses as well as through their eyes. It is well to leave the materials out for the pupils to work with when they have free time. Water will certainly be spilled, but most children clean it up carefully and little damage results.

**Page 247**

The title page can be used to initiate a discussion of boats. Several types are shown here and some of the pupils will be acquainted with one or more of them. Encourage the pupils to tell about boats they have seen and ridden in. Ask them to describe several types—canoes, rafts, large sailing vessels, and warships with which they are acquainted. Pupils may have scale models of different kinds of boats and ships which may be brought in for an exhibit. Pictures, films, and stories can be used to enrich this study.

**Pages 248–249**

These pages take up the problem of why a boat, or any other object that floats, is able to stay on the surface of the water. The paper cup makes a good opening experiment, but the balloon is the most spectacular. Be sure that all the pupils have an opportunity to try pushing the balloon under water. The upward force on it is surprising.

There is an upward force on all objects in water, whether or not the objects can float. The experiment with the bottle of water is increasingly effective as the size of the bottle is increased. If there is a container large enough to hold it, a gallon jug of water shows a great difference between its weight in air and its weight in water. Other objects such as a stone or an iron weight may also be used.

**Pages 250–251**

The experiments on these pages bring in some quantitative aspects of buoyancy. Juice cans and No. 10 cans are large enough to give forces that can be measured in pounds. Small cans are less effective.

Give all the children an opportunity to press downward on the floating can and note the amount of the force developed. Be sure they note the relationship between the upward force and the amount of the can that is beneath water level. Explain that the upward force and the downward force must balance when something is floating.

### Pages 252–253

These pages present applications of the principles developed on the previous pages. If model boats can be brought in, they may be loaded to illustrate more vividly the points brought out by the pictures.

Pictures of ships sometimes show the loading lines. These pictures may be put on display on the bulletin board.

### Pages 254–255

The pupils should have already noticed that the more of a can or a boat there is under water, the greater is the upward force. The experiments on these pages expand this concept.

The first experience is a variation on previous experiments with tin cans. Some pupils may like trying to balance the weight of the bottle against its buoyant force so that the bottle will remain suspended at any level in the water. They will fail because perfect equality is practically impossible to attain, but they can come close.

One concept to be developed by this first experiment is that the maximum upward force is attained when the bottle is completely submerged. This will be further developed to show that the maximum buoyant force depends upon the volume of the bottle when submerged.

The second experiment is designed to show that the maximum upward force is independent of the kind of load and depends only upon the bottle. In each case, the combined weight of the bottle and its load is the same if it is submerged to the same depth.

The third experiment shows that the upward force depends upon the size of the bottle. The maximum upward force for the small bottle is less than the maximum upward forces for larger bottles.

### Pages 256–257

These pages apply the understanding developed on the previous pages. The pupils should be able to recognize that the greater the amount of a boat under water, the greater the upward force becomes, and that larger boats can carry bigger loads than small boats because it is possible to have larger volumes of the larger boats submerged.

### Pages 258–259

The volume of a submarine cannot be changed but its weight can be. By admitting water to tanks in the submarine, the submarine weighs more; by forcing out the water the submarine weighs less. A slight variation in the weight causes the submarine to sink or rise.

Because this method of changing the depth of a submarine is slow, there is usually a device something like the elevator of an airplane at the front of the submarine. When the submarine is travelling forward it will tend to climb or dive as this device is raised or lowered. However, the submarine must be moving for this device to be effective.

Some pupils may be interested in studying the construction of submarines in more detail. They will find good diagrams in encyclopedias. It may be worth while to encourage these pupils to make diagrams on the blackboard and explain them to the rest of the class. The submarine shown in the diagrams on page 259 is the *Nautilus*, the first atomic-powered submarine.

### Pages 260–261

The submarine diver described here is a spectacular and mystifying device to people who do not understand it. Its principle is that of the submarine—by changing the weight to be slightly more than or slightly less than the upward force of the water, the diver sinks or rises.

The weight increases slightly because increased pressure of the cork forces a little water into the dropper. The weight decreases slightly when the pressure is removed because the air in the dropper expands and forces some water out.

The change in weight is very slight. Therefore the dropper must be delicately balanced at the beginning. It should barely float at the surface.

### Pages 262–263

The upward force of salt water on an object is greater than the upward force of fresh water. These experiments demonstrate this fact. The pupils can try other solutions and liquids such as sugar solution and kerosene, to see if these substances also increase the upward force.

One application of the principle is the effect on a ship moving from fresh water to salt. Perhaps some pupils have experienced another application if they have been swimming in salt and fresh water.

### Pages 264–265

Many children have learned to row a boat by the time they are in the fifth grade. If some of these children are in the class, make use of them in studying this section. Ideally, one should use real demonstrations with a boat in a nearby pond or stream. However, an indoor demonstration can be improvised using an orange crate for a boat and a couple of sticks for oars.

### Pages 266–267

In discussing safety in boats, the pupils should be conscious of the factors that can tip over a boat or cause someone to fall out. Unequal loadings of a boat is one of these factors. Children are all too inclined to shift their bodies to one side of a boat to see something in the water, to move around, and even to deliberately tip the boat dangerously. Waves from storms or from rapidly moving ships and motorboats are also dangerous.

The importance of life preservers should be emphasized, because accidents may happen any time and everyone should anticipate them. Pupils should also understand that most rowboats will float even when filled with water; that if they stay with a swamped boat they may be safer than if they try to swim to the shore.

### Pages 268–269

The propeller of a boat is sometimes called the "screw" by people who have boats. In a sense it does "screw" its way through the water much as a wood screw forces its way through wood. Some pupils may see this action readily.

If possible, show the pupils what boat propellers are like by visiting a boat yard or by showing them an outdoor motor. Toy boats also have propellers that can be studied.

The model boat described on page 269 is simple to make and demonstrates propeller action. Encourage pupils to make their own boats and have a race to see which boat goes fastest and which boat goes farthest.

Some ships have paddle wheels instead of propellers of the screw type. Certain pupils may enjoy studying the history of these ships.

### Page 270

Try to show the children the rudders on real boats if possible. Many toy boats have rudders that can be adjusted. Demonstrate some of these toys. The easily-made model shown here also illustrates rudder action effectively. If desired, pupils can put small masts with paper sails on these models and have sailboats for racing.

### Summary Questions

1. Boats and other objects float because the water pushes up enough on them to balance their weight.

2. A submarine can be made to rise by decreasing its weight until it weighs less than the upward force of the water. It can be made to sink by increasing its weight until it weighs more than the upward force of the water. The weight is changed by pumping water into and out from tanks in the submarine.

3. A rowboat can be turned by pulling harder on one oar than on the other. It can be made to turn faster by holding one oar still and pulling hard on the other oar.

4. The propeller of a motorboat pushes back on the water and thus drives the boat ahead.

5. As a ship sails from fresh water to salt water it floats higher because the salt water pushes up more than fresh water does.

6. The pupils can list those rules given on pages 266–267 together with others they have decided upon in their discussions.

7. A big boat can carry more than a little boat because the greater the amount of a boat that can be submerged, the greater is the upward force upon it.

### Follow-up

The extent of the follow-up for this unit depends upon the facilities of the region and the particular interests of the pupils. Where trips can be arranged to see ships of different kinds, to study canal locks and canal boats, or to see boat races, the follow-up may extend through the remainder of the year. If certain pupils show an interest in studying some phase of water transportation, such as the history of steamships, or recreational canoe trips in the province, they should be encouraged to do so.

As pictures of ships and boats are published in magazines, they may be clipped and used on the bulletin board. Sometimes a motion picture dealing with water transportation is shown at local theatres and pupils can report on it.

## POSSIBLE LEARNINGS

Water pushes upwards on objects in it.
As a boat is loaded, it sinks deeper in the water, thus increasing the amount under water and the upward force.
Salt water pushes up more on objects than does fresh water.
Submarines are made to rise and sink by varying their weight.
Everyone should be careful when in boats.
Some boats are steered with rudders.
Motorboats and ships are usually driven by propellers.

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### Films

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Nancy and Roger take a river trip and learn about all kinds of boats.

*Great Lakes Shipping.* National Film Board.

# Flowers and Their Work

## PURPOSE OF THE UNIT

Flowers are often thought of as being ornamental only, and many pupils look upon them as existing for man's pleasure. This unit tries to show how flowers function in the production of seeds and fruits. The unit gives as much attention to inconspicuous forms as it does to the large and colourful flowers. It is desirable that pupils develop a realistic attitude toward the living things of the world and particularly towards man's place in the order of things.

A study of pollination helps to point out the interrelationships that exist between living things and the physical environment. Pupils see how certain insects and plants become highly dependent upon one another, and they see how certain other plants may be equally dependent upon the wind for survival. Many interrelationships are too complex for ready understanding, but those involving pollination are comparatively direct and easy to grasp.

This unit is specifically a part of the study of plant reproduction in this Series. Previous units in the sequence are the first-grade unit "Planting Seeds," and the second-grade unit "Buds," the third-grade unit "Travelling Seeds," and the fourth-grade unit "Growing Plants Indoors." The mechanics of insect pollination are also introduced in this book, Unit One, "Insects That Work Together."

The basic principle of fertilization of the ovule will be utilized again in the sixth-grade unit "Fish Life," in a consideration of animal reproduction.

The material of the unit encourages field observations. It refers to both wild and cultivated species so that pupils in any situations can find things to study. Identification for identification's sake is not stressed. Instead, pupils are given suggestions of things to look for in the many flowers that they will encounter. Thus, some of the broader aims of science education are met.

## PREPARING FOR THE UNIT

Spring is the season we usually think of as being the time to study flowers, and certainly many interesting forms can be found then. There are autumn flowers of considerable interest, however, and the work of this unit can be anticipated by encouraging the pupils to bring in and identify some of the autumn flowers. These flowers can then be referred to when the unit is studied formally.

It is well to introduce the present unit when early spring flowers begin to appear. Interest is high and a long period of follow-up is possible. The exact time for the introduction of the unit will vary with locality and with weather.

No specialized science equipment is needed except hand lenses, but models of flowers, ears of mixed corn, and models of pollen-carrying insects are useful.

The most important part of the preparation will be the location of plants for study. Daffodils and tulips are usually common, and a few blooms may be purchased from a greenhouse if no others are available for study. It is desirable to find an apple tree for extended observation of the development of buds and flowers. Alders and willows can usually be found near a stream or pond. Birches, oaks, maples, and other trees with interesting flowers can be found in woods, fields, and parks.

### List of Materials

Examples of common fruits
Tulip, daffodil, or lily flowers
Single-edged razor blade
Pussy willow or aspen twigs
Grasses in bloom
Cardboard box, black paper, hand lenses
Aspen or other wind-pollinated flowers

## TEACHING THE UNIT

This unit becomes increasingly meaningful as the pupils are shown more applications. It is desirable, therefore, that as many flowers as possible be used during the study of pollination and development of seeds. Many flowers can be brought into the classroom, sometimes in sufficient numbers so that each pupil can study a specimen. Other flowers can be seen on short trips to gardens, parks, fields, and woodlands. Pictures of out-of-season flowers can be found in seed catalogues and flower guides for purposes of comparison.

Many pupils gain much satisfaction from knowing the names of common flowers. They should be encouraged to look in books for the names of flowers and prepare exhibits of these flowers so that others may also learn the names. However, identification for its own sake is not an important outcome of a science programme, and identification should not be pushed so far that some pupils develop a distaste for science because of it.

A few technical science words have been introduced in this unit: "stamen," "pistil," and "ovule." The first two words are known to many pupils both through their outside reading and through references by parents. A large chart of a few kinds of flowers, with these parts labelled, will help the pupils during discussions that use these words. The term "ovule" is one rarely encountered outside of science books. The ovule of a plant is comparable to the unfertilized egg of an animal. It is sometimes called an "egg cell," but botanists do not accept this last term. The ovule is not yet a seed, for a seed develops from a fertilized ovule. "Nectar" and "pollen" have been mentioned before in this book—Unit One, "Insects That Work Together," but these words should be introduced again and redefined.

### Page 271

This page may be used to review understandings that pupils have already acquired. They may discuss honeybees, nectar, and the manufacture of honey. They may recall also the development of apple blossoms and apples from experiences they have had in previous books of this Series.

This page makes a good summary page to be turned to after the work of the unit has been completed. Pupils can explain the function of flowers, the importance of bees in the growing of apples, and why orchardists often maintain hives of bees.

## Pages 272–273

Twig stories, particularly apple twig stories, are often interesting. With a little practice, the pupils quickly learn to identify leaf buds and flower buds. They may check their guesses by putting twigs in water and watching the buds develop. The age of a twig is usually easy to determine by looking for the rings that mark the end of a season's growth. The twig at the top of page 273 is three years old; the twig at the bottom of page 272 is two years old. Twigs of many trees other than apple trees indicate their age the same way. Sugar maple saplings are easily studied.

The flowering and fruiting history of a twig can be told by the scars on the twig. Several blossoms develop from one bud. If none of these blossoms produce fruit, a group of tiny scars will remain when the blossoms fall off. If two or three apples begin to develop but none grow very large before falling off, there will be two or three larger scars in a group. If one apple matures, there will be a single large scar.

It will be noticed that blossoms do not form on new wood at the ends of twigs but on wood two or more years old. It may also be noticed that blossom buds do not form two years in a row in the same place. After a flower bud has opened, whether fruit develops or not, only a leaf bud develops. A year elapses before another flower bud is formed.

After pupils have interpreted a few twig stories they may enjoy mounting twigs on sheets of cards, and giving the story of each one for an exhibit.

## Pages 274–275

The study of the development of flowers into fruits should be based on as many concrete illustrations as possible. Apples, pears, oranges, strawberries, tomatoes, and many other fruits retain recognizable parts of the flowers from which they came. It may also be possible to watch the development of strawberries, peas, and string beans. Some pupils may keep records of the development of fruits in their home gardens and exhibit the sketches at school for the other pupils. Sometimes it is possible to collect examples of the several stages of some fruit such as garden peas, and exhibit these to the class.

## Pages 276–277

Tulip, narcissus, and lily plants have blooms that are large enough to show readily the fundamental parts. These flowers are usually common, too, and enough specimens can be procured so that each pupil has one for study.

In this book, we have not made any effort to identify sepals and petals. In many flowers, such as tulips, the petals and sepals look much alike. In others, such as many members of the buttercup family, there are no petals but the sepals are petal-like. Numerous flowers have neither petals nor sepals. It seems best for individual teachers to deal with this topic according to their own knowledge of botany.

After the pupils have become acquainted with the pistils and stamens on the flowers suggested for study, give them opportunities to identify the same parts of other common flowers. Encourage them to study additional flowers that they encounter.

Some pupils may enjoy making charts of flowers. It is better to have them draw specific flowers than the generalized flowers seen in many books. Perhaps each pupil will make a chart of a different flower.

### Pages 278–279

Encourage the pupils to watch bees and describe their behaviour as they gather nectar. Some problems that the pupils might solve by direct observations are "How does a bee get into a snapdragon?" "Does a bee get nectar from one place or from many places in a dandelion?", "Does a bee visit flowers of one colour or of one kind during a single trip?"

As desired, the work of honeybees may be reviewed here. (See Unit 1.) The life history of bumblebees may also be studied if these insects have not been studied before.

### Pages 280–281

The concept of the fertilization of the ovule as developed on these pages is an important one in science. A few points should be emphasized. In most plants the ovules cannot become seeds if they are not fertilized although there are exceptions. Pollen from one species of plant cannot usually fertilize the ovules of a different species. One grain of pollen fertilizes one ovule only.

It should be possible to bring to school enough pods of peas so that each pupil may have one. The pupils may compare the pod with the blossoms pictured here. They should then open the pod and note the seeds and any undeveloped ovules.

**Pages 282–283**

The idea of sexes in flowers is not a common one, and many adults never realize that there are flowers and even whole plants of opposite sexes. Pumpkin flowers are used to introduce the concept because the flowers are large and showy. It is not likely that these flowers will be available in the spring, however, and for concrete examples we must turn to less conspicuous forms such as willows, cottonwoods, and poplars. If the flowers of these plants can be watched over a period of several weeks, the pupils will see the rapid development of the male flower, the shedding of its pollen, and its early withering. They will see the slower development of the female flower and the formation of seeds.

Encourage the pupils to make drawings of the stages in the development of some of these flowers. They may be exhibited.

**Pages 284–285**

The study of these pages may be followed by the study of the life histories of common moths and butterflies, with special emphasis on the foods of both caterpillars and adults. Some flower guides give information on particular plants that are pollinated by moths and butterflies, together with the names of the latter. (Page 284 shows a black swallowtail butterfly at the top and a cabbage butterfly at the bottom.)

**Pages 286–287**

Wind pollination is so commonplace that pupils should have an opportunity to study many different plants that utilize it. Nearly all the grasses and nearly all the conifers are wind-pollinated. Sometimes the pollen from pine trees is so plentiful it coats the ground and makes a scum on quiet water. Alders produce enormous amounts of pollen early in the spring. The method described here for showing the pollen from grasses is also suitable for other wind-pollinated plants. A twig of speckled alder or a twig of pussy willow put in the box will coat the black paper with yellow pollen as soon as the male blossoms open.

The flowers of grasses are much more interesting than most people realize. A hand lens or a low-power microscope reveals some very beautiful flowers in the heads of grasses.

**Pages 288–289**

It is not likely that corn plants will reach the blooming stage while school is in session. Much of the study will necessarily be done from the pictures and from the former experiences of the pupils. It may be, however, that some ears of dried corn are available. These can be used to show the developed grains and the undeveloped ovules. Ears that show the effect of planting two different kinds of corn near each other may also be shown.

### Page 290

Crossing of closely related forms is commonplace in gardens, but few people plant the seeds, preferring to use pure-bred seed. Plant breeders, however, experiment at length with cross-breeding because new and valuable forms often appear among the offspring. Some pupils may be interested in studying this phase of the subject further by reading of the work of plant breeders.

### Summary Questions

1. Seeds develop in part of the pistil of a flower.
2. The stamen produces the pollen that is needed for seed development.
3. Many plants are dependent upon bees for the pollination of the flowers.
4. Plants that are wind-pollinated include the grasses, oaks, birches, cottonwoods, and poplars.
5. The tassels of a corn plant are the male flowers and the ears are the female flowers.
6. Apples do not develop unless the flowers are pollinated, so many orchardists keep bees or rent the hives during blooming season.
7. A male flower has stamens and produces pollen; the female flower has a pistil and produces the seeds.

### Follow-up

As new flowers bloom and as new plants are encountered, the pupils should be given an opportunity to study them. Often, only a few minutes are needed to look at a new flower and find its stamens and pistils. The pupils should be encouraged to bring in flowers that they find growing wild or in their home gardens, to show others in the class what these flowers are like.

Many pupils like to identify flowers. A good wild flower guide and some flower catalogues kept for ready reference in the classroom, help to meet the interests of these pupils.

## POSSIBLE LEARNINGS

Seeds and fruit develop from flowers.

Pollen is produced on the stamens of a flower.

Ovules develop within the pistil of a flower.

Part of a grain of pollen must enter an ovule before the ovule can develop into a seed.

For some species of plants, pollen is carried from flower to flower by insects; for other species, the pollen is carried by the wind.

Flowers of some species of plants contain both pistils and stamens; in other species there are separate flowers for the stamens and separate flowers for the pistils.

If pollen from the flower of one plant is carried to the flower of a closely related but different appearing plant, the offspring may be unlike either parent plant.

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*American Garden Flowers.* Gladys Pratt. Random House: Toronto, 1943.

Colourful illustrations, adequate descriptions, and how to grow flowers.

*In Yards and Gardens.* Margaret Buck. G. R. Welch: Toronto, 1952. 72 pages.

Pictures and descriptions of the common things that grow near home.

*Play with Leaves and Flowers.* Millicent Selsam. George J. McLeod: Toronto, 1952. 64 pages.

Easy-to-do experiments. Well illustrated.

*What's Inside of Plants.* Herbert Zim. George J. McLeod, 1952. 32 pages.

An explanation of the different parts of plants and how they work.

*What Wild Flower Is it?* Anna Pistorious. Ambassador Books: Toronto, 1950.

A question game to help children to learn the wild flowers.

### Films

*From Flower to Fruit.* Encyclopaedia Britannica Films.

Floral parts and various methods of pollination. Animation shows the complete process of fertilization.

*The Growth of Flowers.* Coronet. Ontario Department of Education: SG-12.

Time-lapse photography shows the marvel of flower development.

*SN-29* *Flowers at Work.* Ontario Department of Education.

The structure and function of the various parts of a flower are shown by means of animated drawings.

# Life in Quiet Water

## PURPOSE OF THE UNIT

The problems of water animals are much the same as those of land animals—the need for food and oxygen, the dangers from predators, the struggle with competitors. But in some ways, aquatic organisms are easier to study. One can set up in an aquarium a miniature world where the inhabitants are little affected by those who watch them. The effects of a single changed factor are often positive. The relation of one organism to another is often simple to understand.

The chief purpose of this unit is to develop an appreciation of the interrelationships of living things with each other and with their physical environment. The subject matter lends itself well to this aim.

Many previous units have dealt with the same theme and many other units contribute in part to the success of this one. Specifically, some of the units are the first-grade unit “An Aquarium,” the third-grade unit “Toads and Frogs,” and the fourth-grade unit “Turtles and Other Reptiles.” All the units which deal with the life histories of insects help also. It may be desirable to review the work of some of these units in connection with the study of certain species collected for this unit.

The work of this unit also helps to meet another important goal of a science programme—the development of an interest in the outdoors. Pupils who have collected water life and studied it are often awakened to the fascination of investigating the things that live around us.

## PREPARING FOR THE UNIT

The best time to introduce this unit is when the water is warm enough so that a wet foot does not represent a problem. However, aquatic life can be collected at any time of the year, even through holes in the ice.

The principal part of the preparation is the location of places to collect water organisms. There are few communities where materials cannot be collected. Rural areas usually have ponds, sluggish streams, drainage ditches, and swampy hollows. Many cities have the same features within short distances of a school. They also have pools in their parks. Fish pools and lily pools in private gardens often have an astonishing variety of inhabitants. Along the seacoast one may study the forms in tidewater pools.

For collecting, the class will need some kitchen strainers and some glass jars with screw tops. If desired, strainers may be mounted on longer handles so that specimens may be collected in deeper water or farther from shore. White enamel pans are excellent for sorting the materials that are collected in the strainers.

Satisfactory aquariums may be made from glass jars that range in size from quart to gallon containers. Several small aquariums are usually better than one large one because many aquatic organisms are predaceous. During a single night a large share of the inhabitants of a mixed aquarium usually disappears.

**List of Materials**

Kitchen strainers
Pans
Glass jars with screw tops
Bowl
Needle
Wire
Aquariums or large glass jars
Cloth or netting
String

## TEACHING THE UNIT

The most desirable approach is a collecting trip for the entire class. The specimens should then be sorted and put in aquariums. The different species can then be studied leisurely and in any order.

Sometimes it is impossible to take a class collecting. One solution to the problem is a trip for a small group after school or on a Saturday. One may also depend in part upon materials collected by pupils working independently; the success of this method depends upon the reliability and interests of a few pupils in the class. The least desirable solution, but sometimes the only possible one, is for the teacher to collect the materials and bring them to school.

It may be interesting to take the class to do their collecting in a swift brook, but it is not recommended that such specimens be brought back to school. Animals that live in swift water usually have high oxygen demands, and they do not survive in aquariums. It is not humane to keep them.

This book has not used an overwhelming amount of technical language, and it has made little effort to classify animals by orders and classes. Many pupils are not ready for this treatment. However, those pupils who show an interest in further study should be encouraged to do advanced reading about the specimens they find. They often develop broad vocabularies and acquire a surprising amount of information.

"Amphibian," "mite," and "parasite" have been set in bold-face type the first time they occur, being the three special science words introduced in this unit.

### Pages 291–292–293

These pages suggest procedures and materials for collecting and studying aquatic life. In planning a trip, some teachers direct the pupils to organize themselves into groups in which each person has a specific responsibility such as collecting, sorting, making notes, or bringing the specimens home. Other teachers divide the class into groups of two, each of which has its own strainer, pan, and collecting jars.

The time needed for collecting specimens is usually short. Five or ten minutes is usually sufficient for accumulating a large number of specimens. The pupils must then be persuaded to put back duplicate specimens; otherwise they will bring back far too many specimens. Back at school, the specimens should be sorted and put into aquariums. This should be done immediately because many aquatic forms do not do well mixed together in small collecting jars overnight.

It is well to put each kind of animal in a separate aquarium unless the forms that do not prey on others are recognized. A bit of cloth tied over the tops of the jars keeps some of the more lively forms from crawling out.

Air-breathing forms do well in almost any situation. Gilled forms should not be put in small containers or crowded, many to the same container. Neither should the containers be put in sunlight or near radiators. The amount of dissolved oxygen in water is small at best and such factors as heat, crowding, and decay quickly exhaust the little there is.

### Pages 294–295

Young dragonflies, the "nymphs" as they are called technically, are often found by scooping up the mud in the bottom of a small pond. Other forms may be found among the plants in the water.

The lower jaw of a large nymph can be extended by pressing it down and forward with a toothpick. The pinchers may be seen at the same time. Put a large nymph in a small aquarium and leave it for two or three days. Then add tiny tadpoles or small insects such as damsel-fly nymphs. The pupils may see the dragonfly capture an animal and eat it.

To show the pupils how a dragonfly nymph takes water into its gill chamber and then expels it, put a large nymph in a saucer of water. Then put a drop of red ink near the rear of the nymph. The pupils will see the red ink being drawn into and then expelled from the gill chamber. The nymph may also become frightened and expel the water with such force that it is forced ahead by jet action.

Dragonfly nymphs are used by many fishermen as bait. They call them, among other names, "perch bugs." Few people realize that these ugly creatures have any connection with the beautiful dragonflies that dart around ponds and lakes.

In spring, one may find the empty skins of the nymphs on stones, posts, and plants, where the insects crawled to transform to adults.

### Pages 296–297

Three methods of obtaining oxygen among aquatic animals are briefly described on these pages. The air breathers use one of these methods, going to the surface for fresh air when their oxygen supply is depleted. Of these animals, some have lungs and breathe in their air through nostrils. The insects usually have a system of tubes, called trachea, that carry the air through their bodies. The openings of these tubes may be under the wings as in the beetles, or in the "breathing tubes," as in the water scorpion.

The animals that take their oxygen supply from the water may have gills in which the blood is separated from the water by a thin skin. Pupils may wonder why insects' gills are not red if there is blood in them. It is necessary to explain to them that insect blood is not red but nearly colourless. The gills of fish are red because their blood is red.

Animals with low oxygen demands may take their oxygen in through their skin. Usually these are very small animals but there are some salamanders that get enough oxygen this way. Frogs get enough oxygen through their skins to keep them alive during the winter when they bury themselves in the mud.

**Pages 298-299**

Water boatmen are very satisfactory residents of an aquarium if there is vegetation upon which they may feed. They will lay eggs and produce several generations through a winter if an aquarium is started in early fall. They are always interesting to watch. (Larger water plants and algae that begin to grow naturally will provide food.)

Backswimmers are also interesting to watch and they will live for long time in a fairly large aquarium, feeding on small animals as they develop. Their success in an aquarium depends upon whether there is enough food for them. In large aquariums well stocked with small insects such as water boatmen there is usually enough food.

Water striders will escape from an aquarium unless it is covered. They feed upon tiny flies and other small insects thrown on top of the water. Note that water striders have six legs whereas spiders, with which they are often confused, have eight legs.

**Pages 300–301**

Adult diving beetles may fly from an uncovered aquarium so one should keep a screen or cloth over it at all times. Whirligig beetles feed on small insects dropped on the surface of the water. Diving beetles feed on small tadpoles, tiny minnows, and water insects. If the adults and the young are kept hungry for a few days, they often attack their prey the moment it is added to the aquarium. Thus pupils will be able to see how a diving beetle captures its food.

Sometimes a large insect that looks a little like a diving beetle is collected. It can be identified as a bug by its beak and by its folded wings. This bug will swim about and feed much like the diving beetles.

**Pages 302-303**

The cases of caddis-fly larvae are always interesting. There are many species and each species has its own way of making a case. The larvae found in quiet water do well in most aquariums. They feed upon tiny green plants that grow on the glass, the rocks, and the vegetation in the aquariums. Pupils enjoy watching them move.

It is possible to remove a young caddis-fly from its case with a pair of forceps. Then the pupils can see the gills and the claws at the end of the body. If the case is put back with the insect, it will quickly crawl inside. It is also possible to pull the case apart and watch the insect rebuild it.

### Pages 304–305

The pupils should study these pages while observing a number of different forms of aquatic life. They may list the animals and then write after each the methods by which it moves about. As new forms are encountered the list can be extended.

Many pupils know about streamlining as applied to airplanes and automobiles. They may now apply it to swift-moving water animals. Fish are not considered in this particular unit, being reserved for a sixth-grade unit, but the pupils may apply their knowledge of streamlining to fish.

### Pages 306–307

The life history of frogs is dealt with in the third-grade unit, "Toads and Frogs." It may be profitable to bring in some copies of *Exploring Science Three* and review this unit.

If tadpoles are captured, they may be kept in large aquariums which are not overstocked. Directions for feeding them and taking care of them are given in the Manual for the third grade.

Salamanders may be brought in. Most salamanders eat small animals but they may not feed in captivity. If the red stage of the red-spotted newt is collected, keep it in a woodland terrarium. The adults should be kept in an aquarium and fed small tadpoles and small insects.

### Pages 308-309

Pond snails do well in most aquariums. They will often lay eggs on the glass. Then the development of the eggs can be watched with a hand lens. Such snails feed upon tiny plants and upon decaying material in the aquariums. Most of the native forms come to the surface for air and may be used in aquariums with other animals without depleting the oxygen. Snails bought in pet shops or snails escaped from fish ponds may have gills.

Clams do not do well in aquariums. If one is collected it is better to examine it and then put it back in the water. A small one may be kept in a pan containing sand and water for a few days. It will move about in the sand but the pupils may not see it move because clams are very sensitive to shadows and vibrations and close their shells at the slightest disturbance. The tracks in the sand can be seen, however.

**Pages 310-311–312–313–314**

The concept of the food chain which always begins with green plants is one of the basic principles developed in this unit. Encourage the pupils to make food chains both for aquatic life and for land life. They may merely write the names, or they may draw pictures to illustrate the chains. Some of the chains may be short, such as man-cow-grass, and some of the chains will be long. The children should include parasites in some of the chains.

**Summary Questions**

1. The book mentions beetles and caddis flies as living through four stages. The pupils may recall from previous units that mosquitoes, bees, and ants also live through four stages.
2. A young dragonfly waits until a small animal comes nearby and then it shoots out its lower lip and grabs the animal with the pinchers at the end of its lip.
3. A clam has a muscular foot that it puts out between its shells. It uses this foot to pull itself along, much as an earthworm moves.
4. Some water animals get oxygen by going to the top of the water to take in air; some take oxygen from the water through their gills or their skin.
5. Green plants are at the beginning of all food chains.
6. Parasites are animals or plants that get their food from other living things that are larger than themselves.

**Follow-up**

Additional field trips to new collecting sites represent the best kind of follow-up for work of this type. It may also be possible to visit a museum that has various forms of water life, both living and preserved, on display.

Another phase of the follow-up is the continued study of the specimens that are kept in the aquariums. Records may be kept of the reactions of these specimens. Pupils may write stories and make pictures of them. New species may be added by pupils who have done independent collecting and these specimens may be studied.

## POSSIBLE LEARNINGS

Water animals need oxygen.

Some water animals get oxygen from the air, others use oxygen that is dissolved in water.

Some water insects live through four distinct stages, others change more gradually.

Many water animals feed on other animals, but all are dependent upon green plants.

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*Along the Brook.* Raymond Fuller. Longmans, Green: Toronto, 1931. 81 pages.

The plants and animal life along a stream.

*Beginner's Guide to Fresh Water Life.* Leon Hausman. McClelland and Stewart: Toronto, 1950. 128 pages.

The inhabitants of swamps, ponds, lakes, and streams are described.

*Field Book of Ponds and Streams.* Ann Morgan. McClelland and Stewart: Toronto, 1930. 448 pages.

The teacher and better students will find this valuable in studying life in fresh water.

*Let's Go to the Brook.* Harriet Huntington. Doubleday: Toronto, 1952. 88 pages.

The story of a brook and of the life in it and along it.

### Films

*SB-13 Life in a Pond.* Ontario Department of Education.

Outstandingly clear colour photography presents pond life in action.

*SN-116 Life Along the Waterways.* Ontario Department of Education.

Beautiful colour photography depicts the many forms of plant and animal life found near the streams, ponds, rivers, and marshes that make up a waterway system.

# List of Science Materials and General References

# List of Science Materials

## *(Class of Thirty Pupils)*

| QUANTITY | ITEM | REMARKS |
|---|---|---|
| 2–15 | hand lenses | low-power; usable in every grade |
| 2–15 | thermometers | common household type, one outdoor type |
| 1–2 | aquariums | rectangular, medium sized |
| 2–15 | dry cells | standard 1½-volt type |
| 2–30 | miniature sockets | for flashlight bulbs |
| 2–30 | flashlight bulbs | two-cell or 2.5-volt bulbs |
| 1–4 | bells or buzzers | for use with dry cells |
| 1–4 | push-button switches | for door bells |
| 1–4 | knife switches | single pole, single throw type |
| 1–2 | prisms | equilateral glass prisms |
| 1 | globe | eighteen-inch size |
| 1 | two-hole stopper | to fit a small bottle |
| 4 ins. | glass tubing | two-inch lengths to fit above stopper |
| 3 ft. | rubber tubing | length to fit above glass tubing |
| 2–15 | kitchen strainers | |
| 1 | electric lamp and cord | socket with flat base preferred |
| 1 | electric hot-plate | |
| 1 set | scales | platform spring balance preferred |
| 1 | fire extinguisher | for safety during experiments with fire |
| 100 ft. | insulated wire | No. 24 preferred, double cotton-covered or nylon-covered |
| 20 lbs. | plaster of Paris | must be quick-setting |
| 4 ozs. | alcohol | denatured or wood alcohol |
| 4 ozs. | iodine solution | for starch testing |
| 10 lbs. | Portland cement | |
| 2–4 | hammers | one geology hammer desirable; others carpenter's hammers |

| QUANTITY | ITEM | REMARKS |
|---|---|---|
| 1 | hand drill and bits | for one-eighth to one-fourth inch holes |
| 1 | saw | cross-cut |
| 2–4 | nail-sets | assorted sizes |
| 2–8 | screwdrivers | small, assorted sizes |
| 2–4 | pliers | side-cutting preferred |
| 1–2 | metal snips | good quality |
|  | round-head screws | assorted sizes in short lengths |
|  | round-head stove bolts | slightly longer than thickness of the question board panel in Unit 8 |
|  | nails | assorted |
|  | screw eyes | small |
|  | faucet washers | fibre |
| ½ pt. | black paint | quick-drying |
| 1 oz. | light oil | machine oil or kerosene |
|  | rubber bands | assorted |
|  | rubber balloons | small |
|  | paper clips |  |
|  | gummed tape |  |
|  | cellophane | clear and coloured |
|  | candles | large ones such as plumbers' candles |
|  | matches |  |
|  | paraffin |  |
|  | red ink |  |
|  | Bristol board | assorted colours |
|  | gummed paper stars | silver |
| 1–2 | panel for question board | about one-quarter inch thick, eighteen by twenty-four inches |
| 1–15 | medicine droppers |  |
| 1 set | sedimentary rocks | local forms if possible |
| 1 set | fossils | common forms |
| 1 | sprayer | hand insect sprayer may be borrowed |
| 2–15 | small mirrors | pocketbook size |
| 1 | paring knife |  |
|  | spoons |  |
|  | paper cups |  |

| QUANTITY | ITEM | REMARKS |
|---|---|---|
| 1 | saucepan | two-quart size |
| 1–4 | pans | shallow, white enamel preferred |
| 1 | measuring cup | |
| 1 | trowel or shovel | may be borrowed |
| 1 | flashlight | may be borrowed |
| 1 | dark umbrella | need not be in good condition |
| 1 | soap-bubble set | may be borrowed |
| 1 | can opener | for triangular holes |
| 2–15 | sewing needles | fine |
| 5 lbs. | white sugar | |
| 1 lb. | brown sugar | |
| 1 lb. | cornstarch | |
| 1 lb. | table salt | |
| 1 pkg. | dessert gelatin | |
| | corks | assorted sizes |
| | glass jars with caps | assorted sizes |
| | bottles with caps | assorted sizes |
| | milk bottles | assorted sizes |
| | tin cans | assorted sizes |
| | ink bottles | |
| | drinking glasses | |
| | ice-cream containers | round, cardboard |
| | cardboard cartons | assorted |
| | shoe boxes | |
| | plant pots | small, assorted sizes |
| | scraps of lumber | white pine preferred |
| | sawdust | |
| | sand | |
| | gravel | |
| | soil | potting soil for plants |
| | cloth | scraps of wool |
| | cloth netting | scraps |
| | copper screening | small scrap |
| | copper wire, bare | odd lengths |
| | string | |
| | spools | |
| | wire coat hangers | |
| 1 lb. | fresh fruit | plums or cherries for making jam |
| 2 | oranges | |

| QUANTITY | ITEM | REMARKS |
|---|---|---|
| 1 | lemon | |
| | apples | both green and ripe |
| | house plants | coleus suitable; one green and white plant needed also |
| | radish seeds | |
| | oat seeds | |
| | sprouting potatoes | |
| | sprouting carrots | |
| | flowers | tulips, daffodils, or lilies in season |

# General References for the Teacher

*Audubon Nature Bulletins.* Prepared and published by the National Audubon Society: New York. 4 pages each.

These bulletins contain background information on the things of the natural environment. List sent by the Society on request.

*Cornell Rural School Leaflets.* Prepared and published by Cornell University, Ithaca, New York.

These leaflets contain background information and suggestions for teaching nearly every science topic. Consult the list of titles.

*Fieldbook of Natural History.* E. Laurence Palmer. McGraw-Hill: Toronto, 1949.

Condensed information on a wide variety of plants, animals, rocks, and minerals.

*Golden Treasury of Natural History.* Bertha Parker. Musson: Toronto, 1952.

Interesting background for the teacher.

*Handbook of Nature Study.* Anna Botsford Comstock. Thomas Allen: Toronto, 1947 ed.

Excellent reference on common plants and animals together with teaching suggestions.

*Man in Structure and Function.* Fritz Kahn. McClelland and Stewart: Toronto, 1943.

A beautifully illustrated work on the human body written so anyone can understand it. There is an excellent chapter on alcohol and tobacco.

*Elementary School Science and How To Teach It.* Glenn O. Blough and Albert J. Hugget. Macmillan of Canada, 1951.

Among the main headings are: The Earth and the Universe; Living Things; Matter and Energy; Conservation of Our Resources; Fire and Prevention; The Behaviour and Habits of Animals.

*Nature Notebook.* Robert Candy. Thomas Nelson: Toronto, 1953.
Detailed, accurate information about life in woods and streams and notes on outdoor crafts enrich a father-and-son field trip. Beautifully illustrated by the author.

*Science for the Elementary School Teacher.* Gerald S. Craig. Ginn: Toronto, 1947.
Background information on a variety of science fields together with specific suggestions for teaching the material.

*Making and Using Classroom Science Materials in the Elementary School.* Glenn O. Blough and Marjorie H. Campbell. Macmillan of Canada: Toronto, 1954. 229 pages.
A practical book with descriptions of appropriate activities including photographs and drawings and carefully prepared lists of source material.

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*Natural Science Through the Seasons.* J. A. Partridge. Macmillan of Canada, Revised Edition, 1955.
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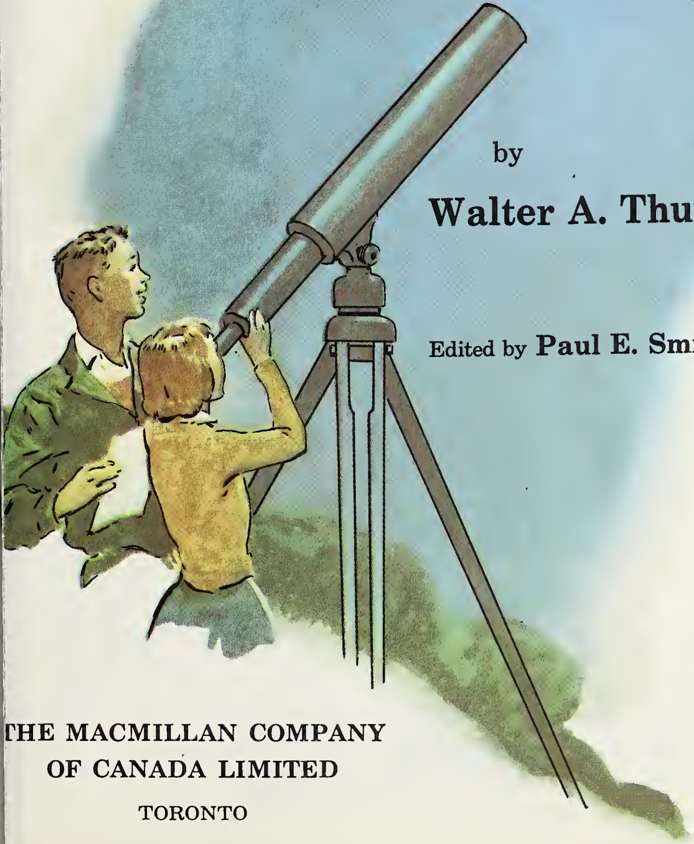
# EXPLORING SCIENCE *Five*

by

**Walter A. Thurber**

Edited by **Paul E. Smith**



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## EXPLORING SCIENCE SERIES

*One · Two · Three · Four · Five · Six*

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## Contents

Insects That Work Together ~ 4
Controlling Fires ~ 25
Streams at Work ~ 49
Sugar and Starch ~ 71
Warm Weather Indoors ~ 93
Animal Tracks and Signs ~ 113
The Winter Sky ~ 137
Electric Circuits ~ 155
Rainbow Colours ~ 179
Plants and Light ~ 199
Lifting Things ~ 223
Boats ~ 247
Flowers and Their Work ~ 271
Life in Quiet Water ~ 291
Index ~ 316

*Illustrated by*

**Paul Dudley**
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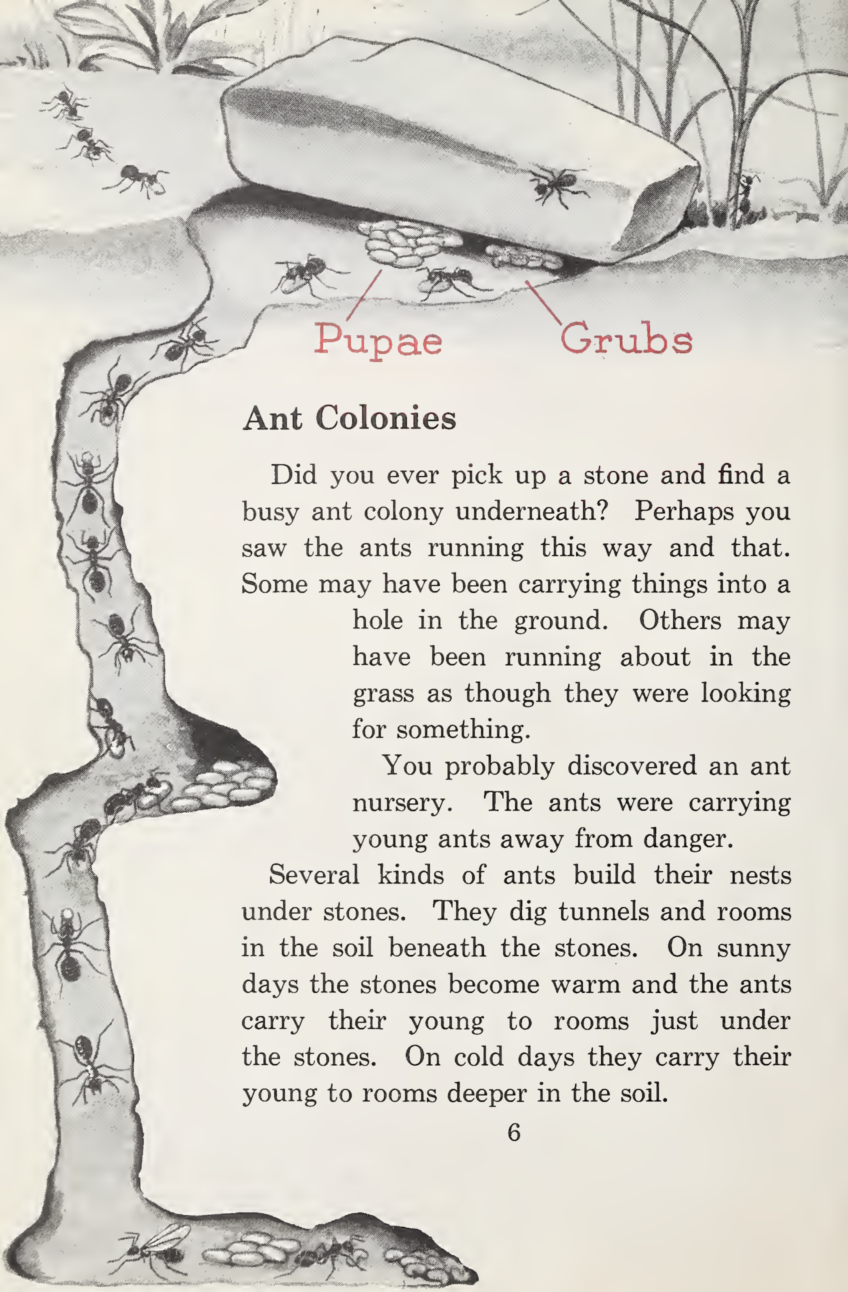
# Insects That Work Together

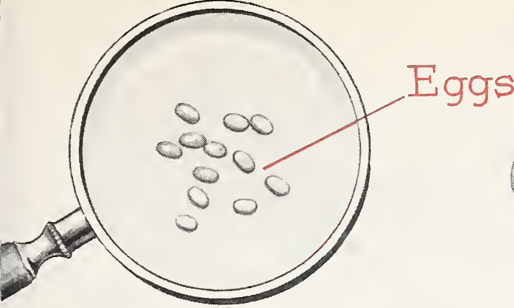


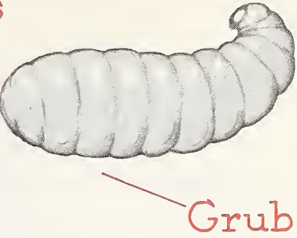
## Ant Colonies

Did you ever pick up a stone and find a busy ant colony underneath? Perhaps you saw the ants running this way and that. Some may have been carrying things into a hole in the ground. Others may have been running about in the grass as though they were looking for something.

You probably discovered an ant nursery. The ants were carrying young ants away from danger.

Several kinds of ants build their nests under stones. They dig tunnels and rooms in the soil beneath the stones. On sunny days the stones become warm and the ants carry their young to rooms just under the stones. On cold days they carry their young to rooms deeper in the soil.

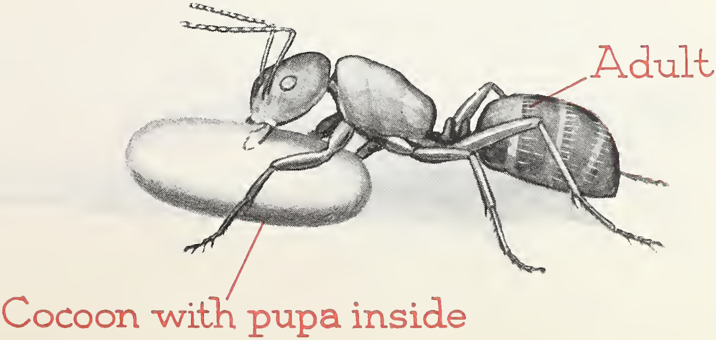




Young ants do not look like adult ants. There are four stages in the lives of ants as there are in the lives of flies and butterflies.

The **egg** is the first stage. The egg hatches into a **grub.** The grub eats and grows to its full size. Then it makes a **cocoon** and changes into a **pupa** inside the cocoon. Later the pupa changes to the **adult** stage. Adult ants do not grow any more.

The young of most insects must take care of themselves as soon as they hatch from the eggs. But young ants are cared for by adult ants. The adults find food for the grubs, they carry the grubs and the cocoons to warm places, and they try to keep the young ants from danger.

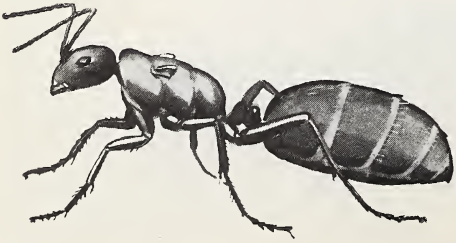


## Keeping Ants

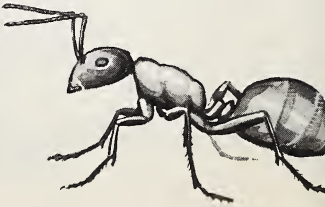
Find an ant hill. Dig around the hill and lift off the top. Then dig out the inside. If the weather is cool, you will find most of the ants in the rooms.

Look carefully for an ant that is larger than the other ants. This is the **queen** ant that lays the eggs. You will need a queen ant for your ant nest.

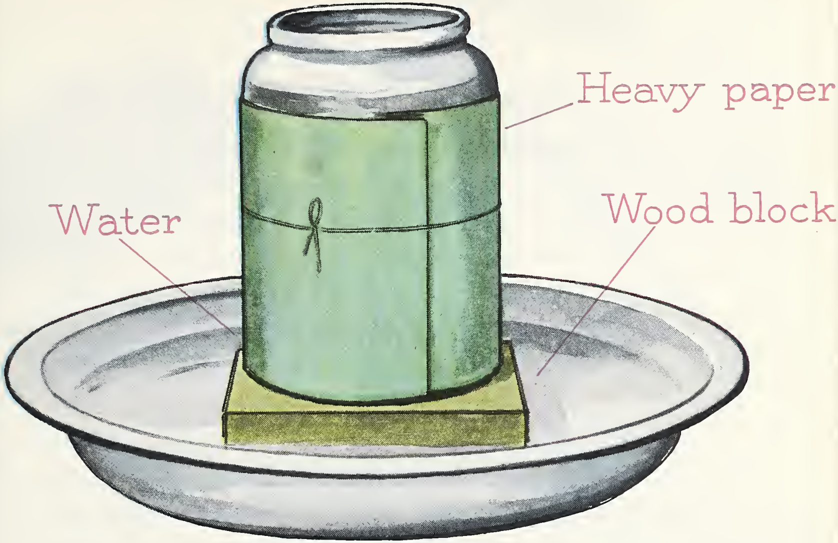
Fill a glass jar with soil from the ant hill. Put in the queen and some other adult ants. Put in some grubs and some cocoons. Place the cover on the jar.



Queen



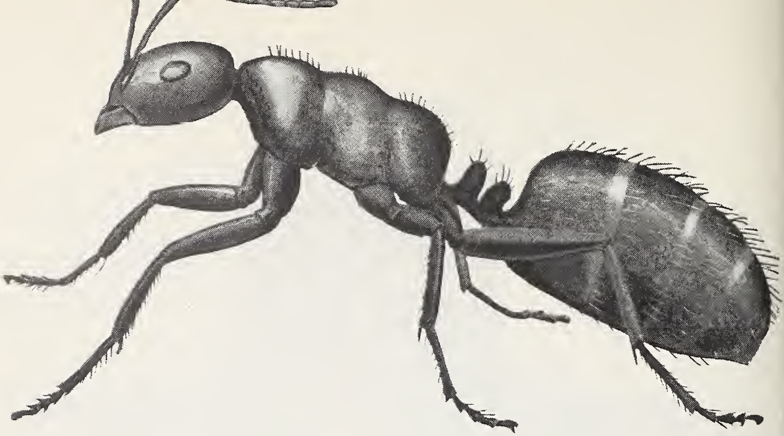
Worker



Set the jar on a block of wood in a pan of water. Wrap a sheet of heavy paper around the jar. Then take off the lid of the jar.

Feed the ants bits of bread, cake, and sugar. Give them honey mixed with water. Also give them dead insects.

After a few days you can take off the heavy paper for a few minutes. Watch the ants in the tunnels and the rooms that they have dug. Do not leave the heavy paper off for a long time because the ants do not like light. They may dig new tunnels where you cannot see them.

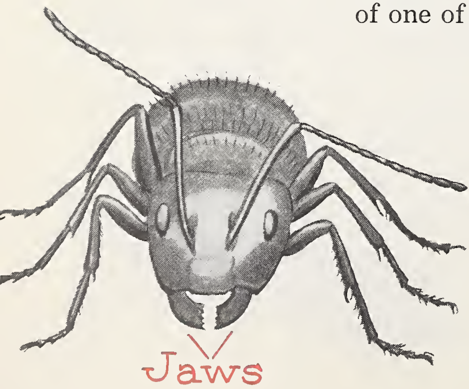


## The Bodies of Ants

Look at one of the ants in your ant nest. How many legs does it have? From what part of its body do the legs grow? How many parts does the ant's body have?

Watch an ant carrying something. How does it carry things?

Ants have strong jaws. They use their jaws to tear up food, to fight enemies, and to pick up things. Can you see the jaws of one of your ants?



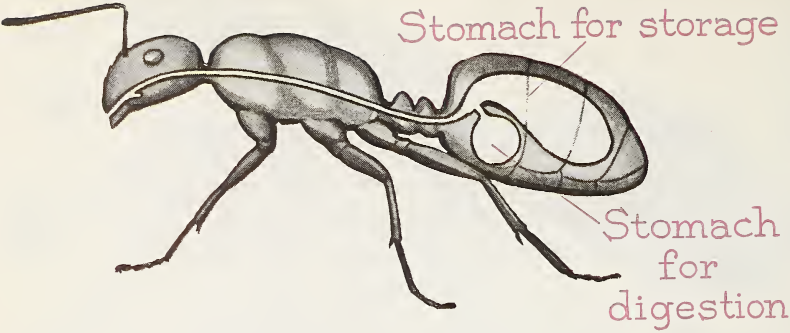
## Winged Ants

Sometimes you will see ants with wings. They are usually crawling near the opening of the nest when you see them. Now and then a winged ant will fly away.

These winged ants are males and females ready to start on their mating flight. They fly high in the air and usually come back to earth far from the place where they started.

The males soon die, but the females are now queens. Each queen bites off her wings and starts to build a nest alone. She lays eggs and takes care of the grubs that come from the first eggs.

All the ants that come from the first eggs are **workers.** As soon as they become adults, the workers begin to gather food, make the nest larger, and take care of the young ants. From then on, the only work of the queen is laying eggs.

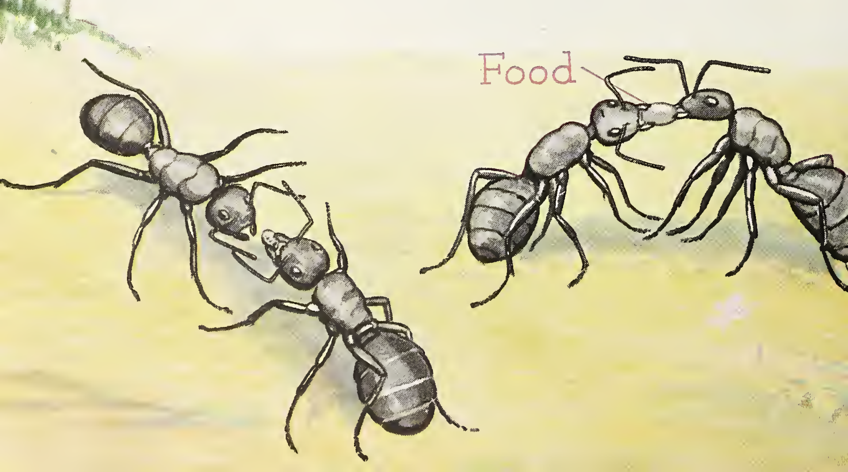


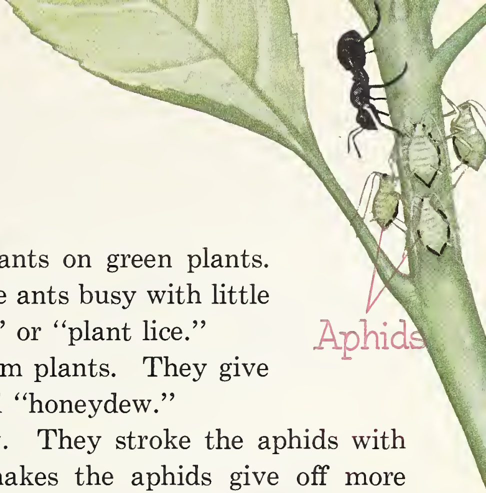
## The Food of Ants

Ants eat many things. They drink the sap of plants. They chew up bits of animals and suck out the juices. They can swallow only liquid foods.

Some of the food an ant eats goes into the stomach used for digestion. But most of the food goes into a large stomach used for storage. This food is taken back to feed other ants in the nest.

When an ant is hungry, it touches a food-carrying ant with its feelers. The food-carrying ant then gives out a drop of liquid food for the hungry ant.



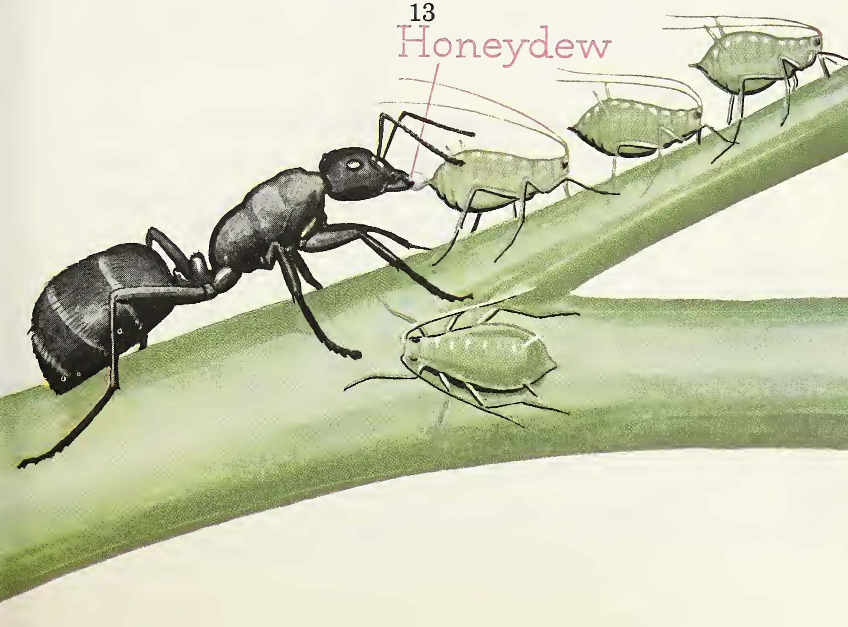


You will often see ants on green plants. Sometimes you will see ants busy with little insects called "aphids" or "plant lice."

Aphids suck sap from plants. They give off a sweet juice called "honeydew."

Ants like honeydew. They stroke the aphids with their feelers. This makes the aphids give off more honeydew. Then the ants swallow the honeydew.

Some kinds of ants take care of the aphids. They try to protect them from enemies. They carry them to new plants. One kind of ant carries the aphids into tunnels for the winter. There, the aphids suck sap from the roots of plants.

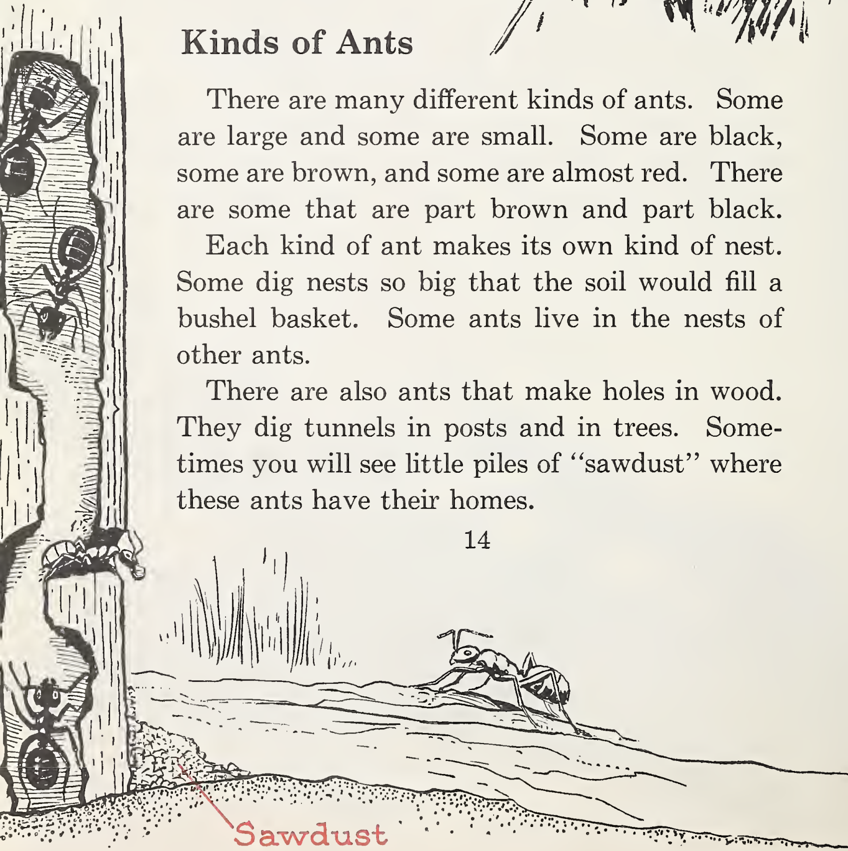


## Kinds of Ants

There are many different kinds of ants. Some are large and some are small. Some are black, some are brown, and some are almost red. There are some that are part brown and part black.

Each kind of ant makes its own kind of nest. Some dig nests so big that the soil would fill a bushel basket. Some ants live in the nests of other ants.

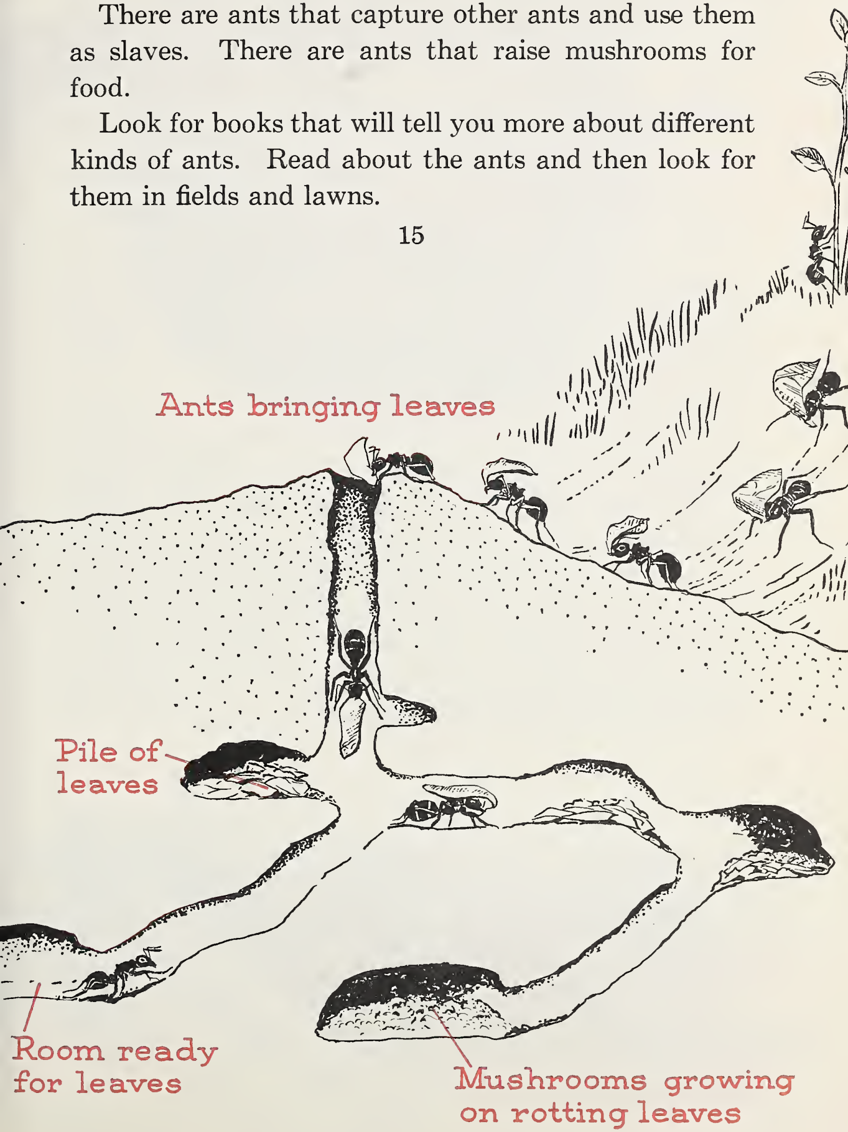
There are also ants that make holes in wood. They dig tunnels in posts and in trees. Sometimes you will see little piles of “sawdust” where these ants have their homes.



There are ants that gather seeds, store them for winter, and grind them into flour before using them.

There are ants that capture other ants and use them as slaves. There are ants that raise mushrooms for food.

Look for books that will tell you more about different kinds of ants. Read about the ants and then look for them in fields and lawns.



## Wasp Colonies

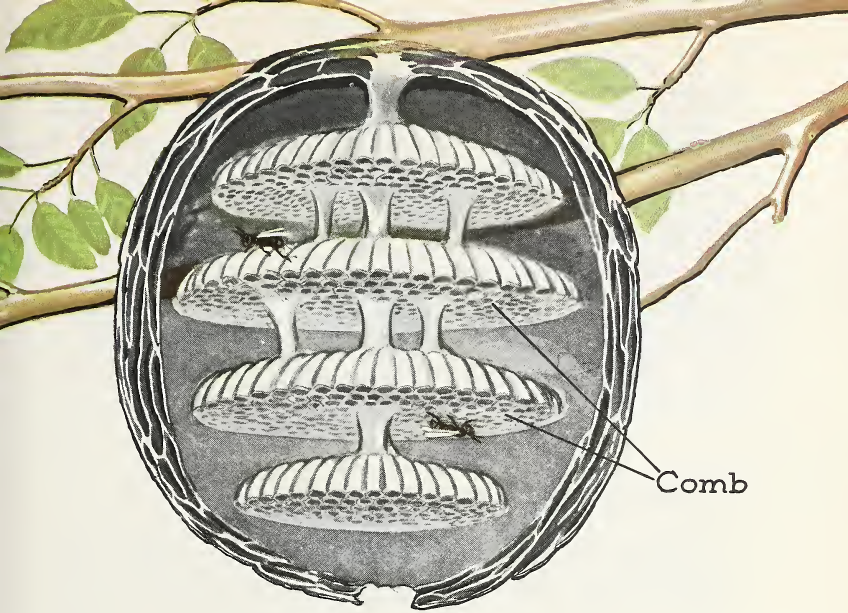
Perhaps you have seen paper nests like the one in the picture above. You will find them in trees and in buildings.

These nests are made by some kinds of wasps. The wasps chew off bits of old wood. They chew the wood into fine pieces and stick the wet pieces together. Find out how we make paper.

The queen starts the nest in the spring. Her first eggs hatch into females that are workers. The workers gather food, make the nest larger, and take care of the young wasps.

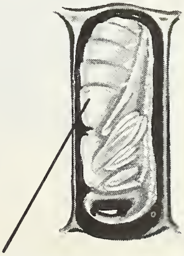
In late summer, some of the eggs hatch into males and young queens. The young queens mate and crawl into protected places for the winter. These queens are the only wasps that live through the winter. All the others die when cold weather comes.

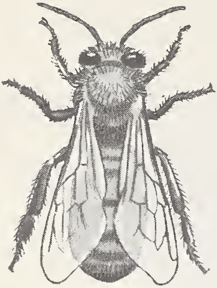
Wasp adding paper to the nest



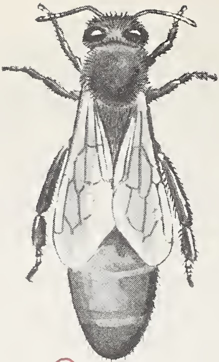
Wasps, like ants, live through four stages. The eggs are laid in a paper comb that looks something like a honeycomb. The eggs hatch into white grubs.

The grubs are fed by the worker wasps. They grow to full size and then spin cocoons. They change into the pupa stage inside the cocoons. At the end of the pupa stage they come from the cocoons as adult wasps.

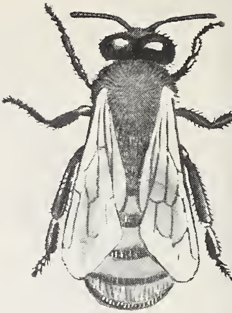




Worker



Queen

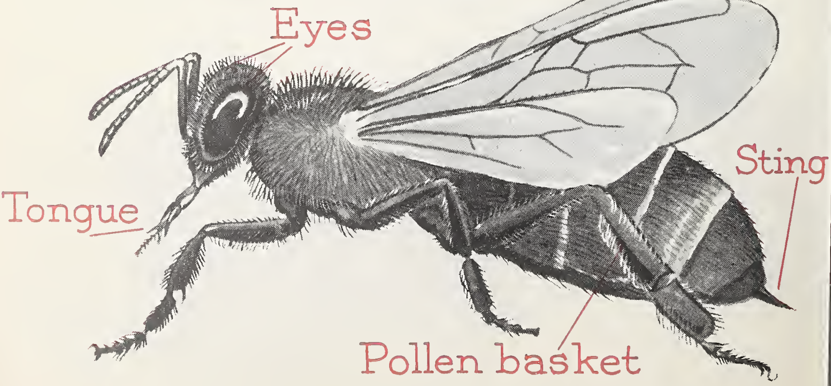


Drone

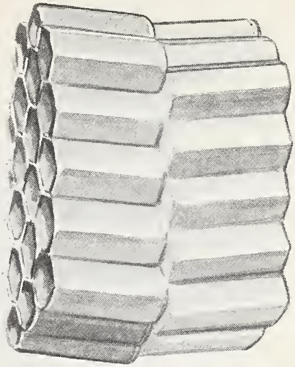
## Honeybees

There are three kinds of bees in a hive. There is an egg-laying female called the queen. There are females called workers that do the work of the hive. There are a few males called **drones.**

Sometimes there are young queens and young males in a hive. The young males go on mating flights with the young queens. Then one of the young queens takes some of the workers with her to start a new hive.



## Honeycomb

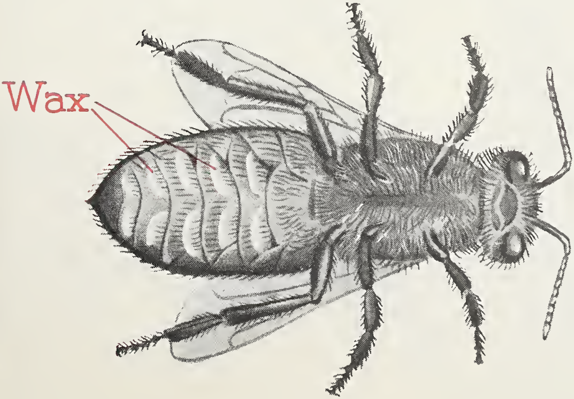


The comb is an important part of the hive. Food is stored in parts of the comb. Eggs are laid in other parts of the comb.

The comb is made of wax. Worker bees are the only insects that can make this kind of wax. Even man cannot make it.

The wax comes from the underside of the workers. They give off the wax when a new comb is needed. They take the little pieces of wax and form them into the shape of the comb.

Study a piece of honeycomb and look at the picture above. How many sides has each cell in the honeycomb? How are the cells fitted together?



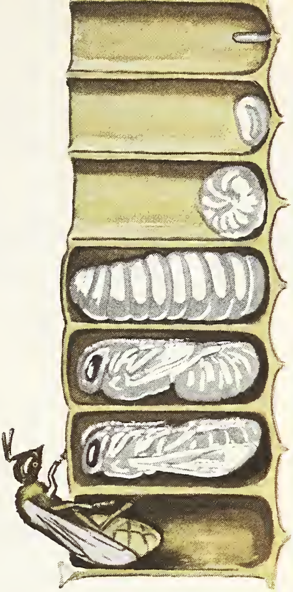
## Queen Bees

Queen bees do not do much except lay eggs. They do not even feed themselves or clean themselves.

The queen bee does not have much time to do anything except lay eggs. In summer, a queen may lay more than a thousand eggs a day.

When the queen rests, worker bees feed her and clean her.

## Young Bees



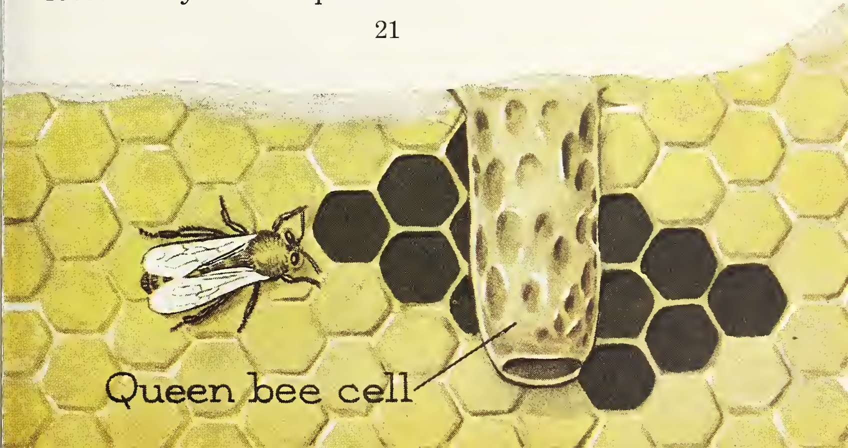
The eggs hatch into tiny white grubs. Workers feed honey and **pollen** to these grubs.

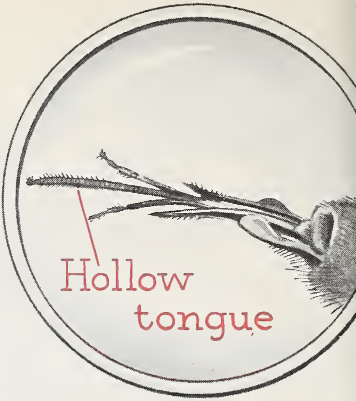
The grubs grow rapidly. Soon they almost fill their cells. Then each grub spins a cocoon and changes into a pupa. At the end of the pupa stage the bees change into adults.

Most young bees become workers. They come from cells about the size of honey cells.

Sometimes the workers make larger cells and the queen bee lays eggs in these cells. The young bees in these cells become drones.

The workers also make a few cells that are much larger and much different in shape from the cells in the combs. The young bees in these cells are fed different food. They become queens.



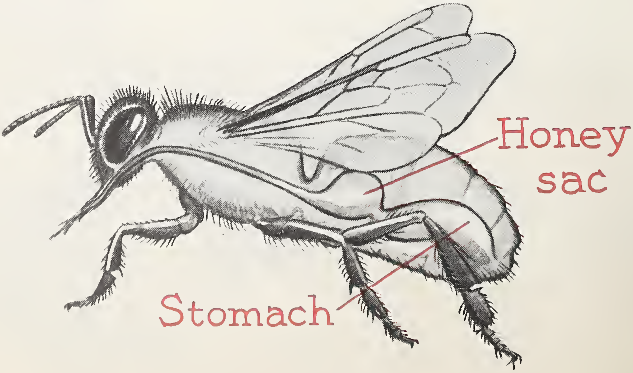


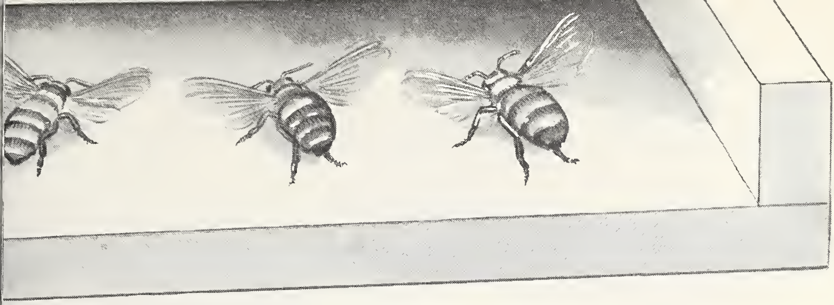
## Bees at Work

Most of the older worker bees leave the hive to look for food. They get their food from flowers.

Each worker has a long hollow tongue. The bee puts this tongue deep into a flower and sucks up the sweet juice called **nectar.**

The worker bee puts the nectar into a honey sac. If she is hungry, she may let a little of the nectar go into her stomach. She carries most of the nectar back to the hive to feed the other bees and to make into honey.



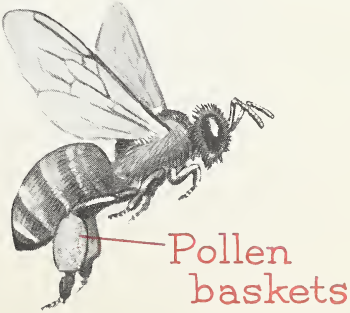


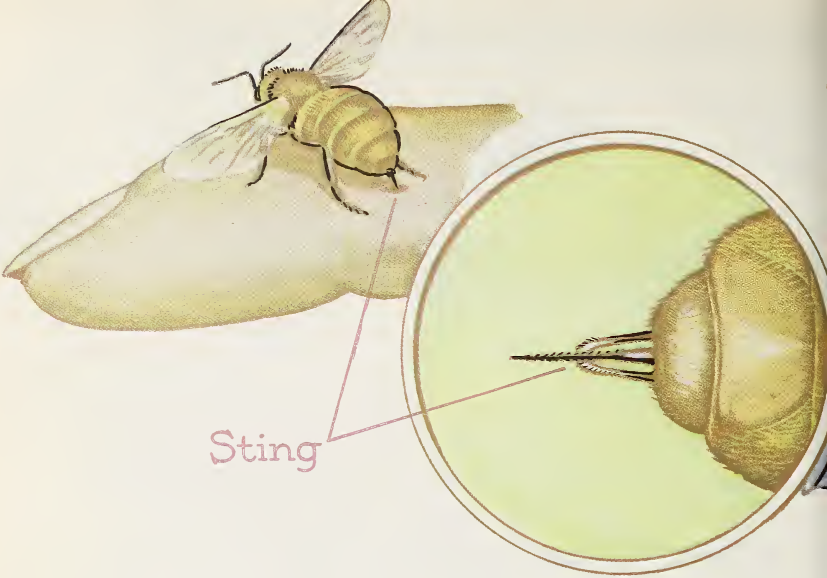
The nectar is not honey at first. It begins to change in the honey sac of the worker bee. After the nectar has been put into the honeycomb, it keeps on changing.

At the same time, water is evaporating from the nectar. This makes the nectar thicker. Worker bees make the water evaporate faster by standing at the opening of the hive and fanning air through the hive with their wings.

At last the nectar becomes honey. The workers then put a cap of wax on the cell. The bees eat this stored food in winter when there are no flowers.

Bees take pollen as well as nectar from the flowers. Pollen is the yellow dust that you can see in many kinds of flowers. Bees carry the pollen in baskets on their hind legs. They use the pollen for food.



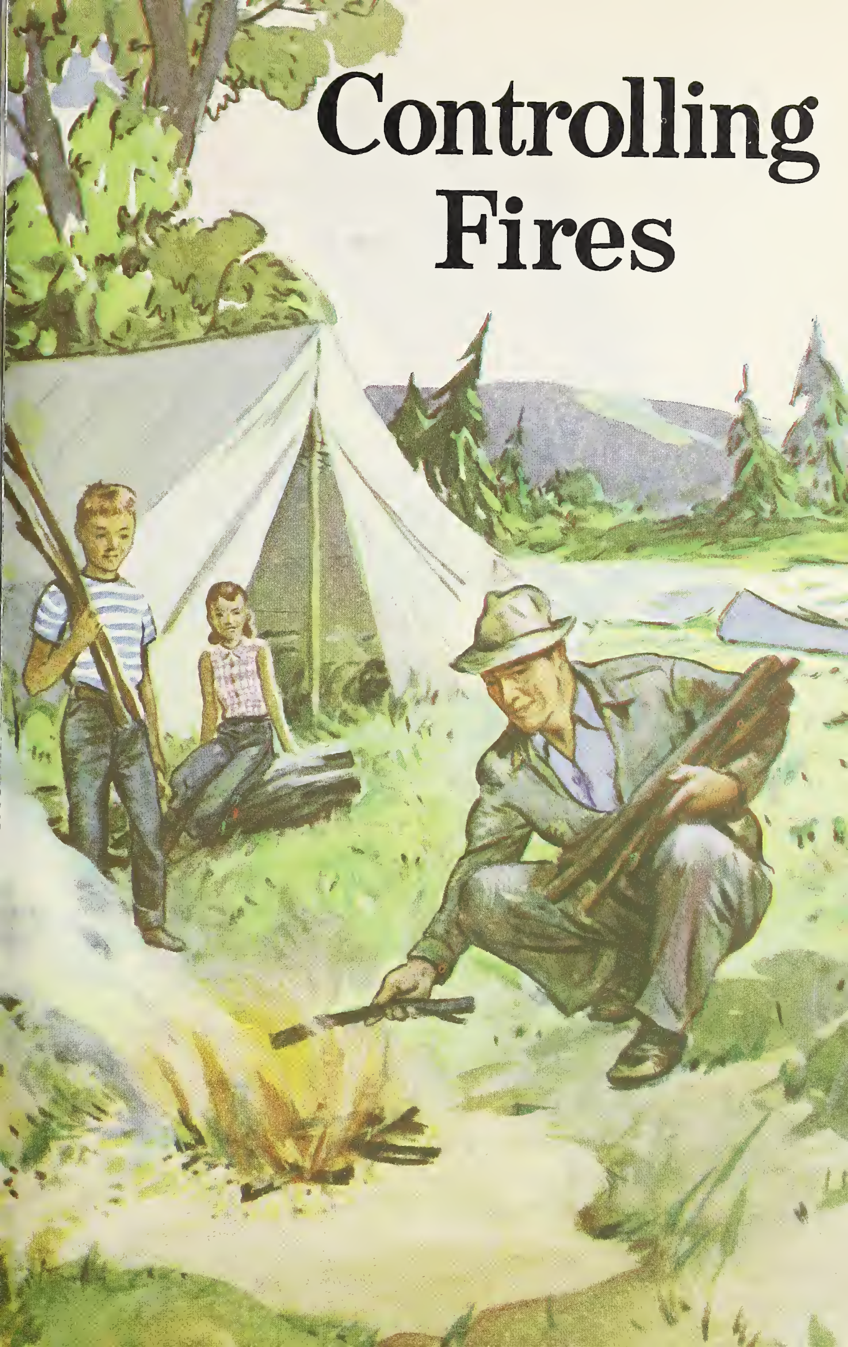


Worker bees also protect the hive. Each worker has a sharp sting and a poison gland at the back of the body.

The worker jabs the sting into an enemy and forces a poison through the sting into the hole. If bees did not have these stings, they could not keep their honey very long.

1. How many stages are there in the life of an ant?
2. Which ant in a colony lays the eggs?
3. How do ants carry food to the nest?
4. What happens to wasps in winter?
5. Where do bees get the wax for the honeycomb?
6. What are some things that worker bees do?
7. How do paper wasps make paper?

# Controlling Fires



## Starting a Fire

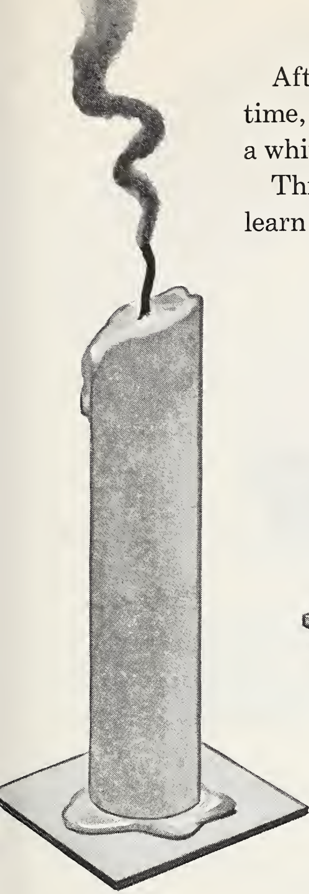
A fire needs heat to start it burning.

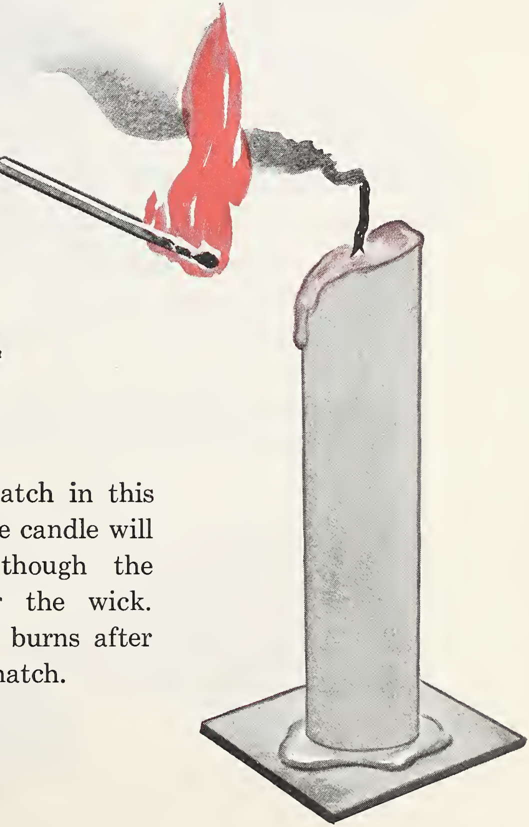
We often start a fire with the heat of a match. The match gives off heat energy. A few experiments will show you that heat energy is needed to start fires.

Hold a lighted match close to the wick of a candle. Watch the wick closely. You will see that the candle does not begin to burn until the wax on the wick melts. The wax had to be heated before it would burn.

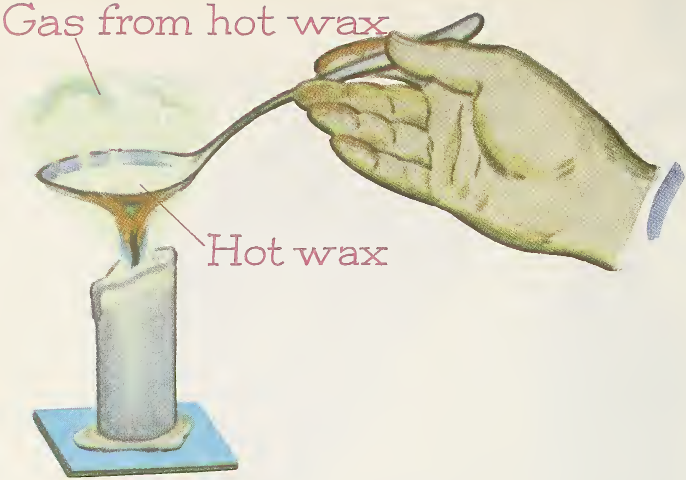
After a candle has been burning for a time, blow out the flame. You will see a white "smoke" leaving the warm wick.

This is not real smoke. We will learn what it is later.





Hold a lighted match in this white "smoke." The candle will light again even though the match is not near the wick. The white "smoke" burns after it is heated by the match.

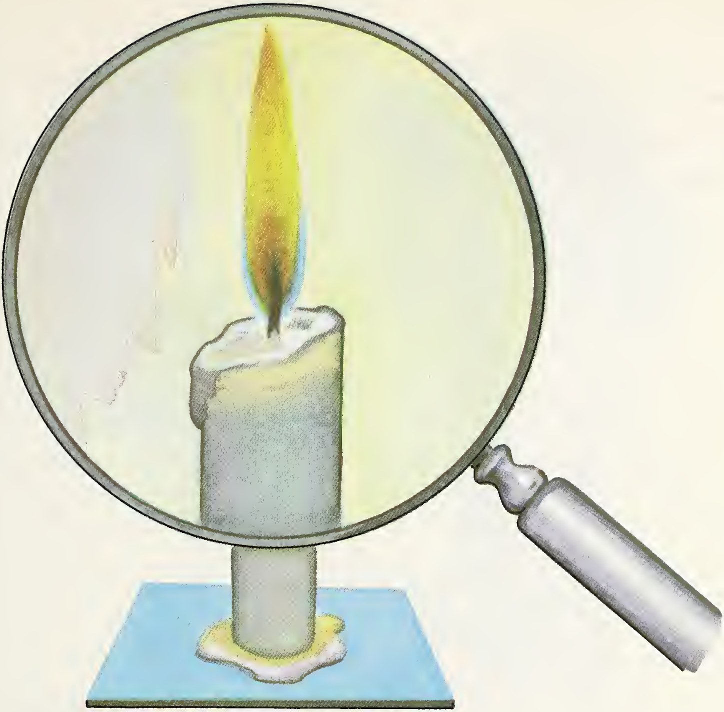


Put a drop of candle wax in a spoon and try to light it with a match. You will find that the cool wax does not burn.

Hold the spoon over a candle flame to give the wax some heat energy. The wax will melt, and then it will give off a white "smoke." The heated wax is evaporating. It is changing to a gas.

Hold a lighted match in the "smoke." Does the gas burn?

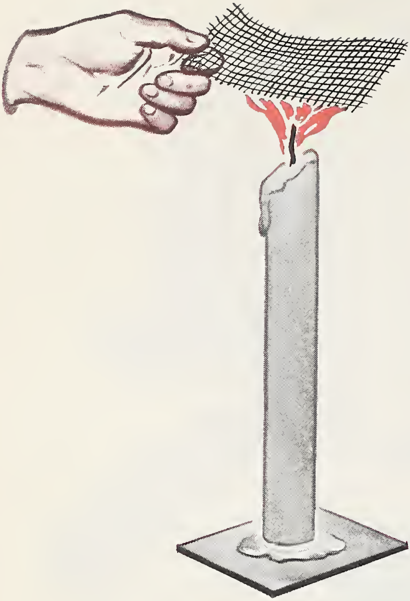
Set the spoon of burning wax on a wet cloth to cool it. What happens? Can you tell why?



Look at a candle flame with a hand lens. You will see that the flame is above the wick. The solid wax and the melted wax do not burn. The part that burns is the gas around the wick. A candle flame is a burning gas.

To light the candle, you give it enough energy to melt some of the wax and change it into a gas. Then the flame gives off enough energy to melt and evaporate more of the wax.

Look at the flame closely. What colours do you see? Where are these colours? Have you seen flames with other colours? Where?

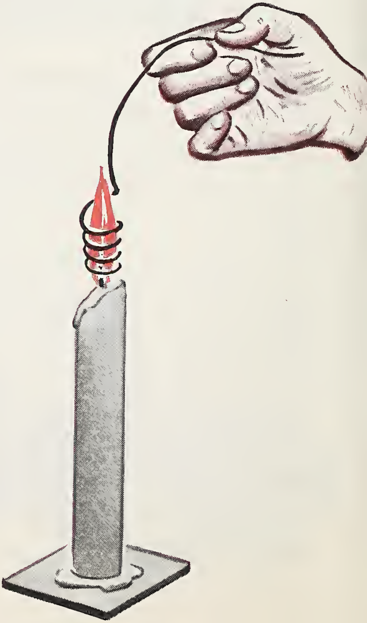


## Cooling a Flame

Hold a piece of metal screen in a candle flame. The screen cools the gas that goes through it. Does the gas burn above the screen?

Hold a lighted match in the gas above the screen. Does the gas burn now? Can you tell why?

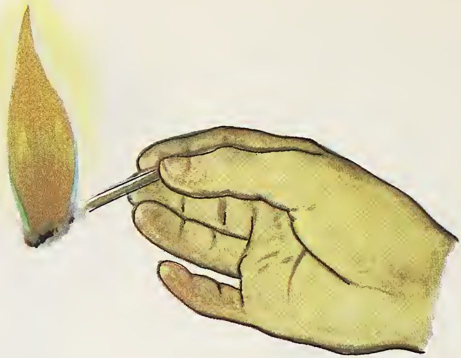
Make a small coil of wire as shown in the picture. Lower the coil over the flame of the candle. The wire takes some of the heat from the flame. If it takes away enough heat, it will put out the flame.



Blow gently on a candle flame. You can make the flame bend to one side without going out. Blow a little harder and the flame will go out.

Your breath is cooler than the flame. It takes heat from the flame. When the flame is cooled enough, it stops burning.

Can you think of other fires that are put out when cool air is blown on them?

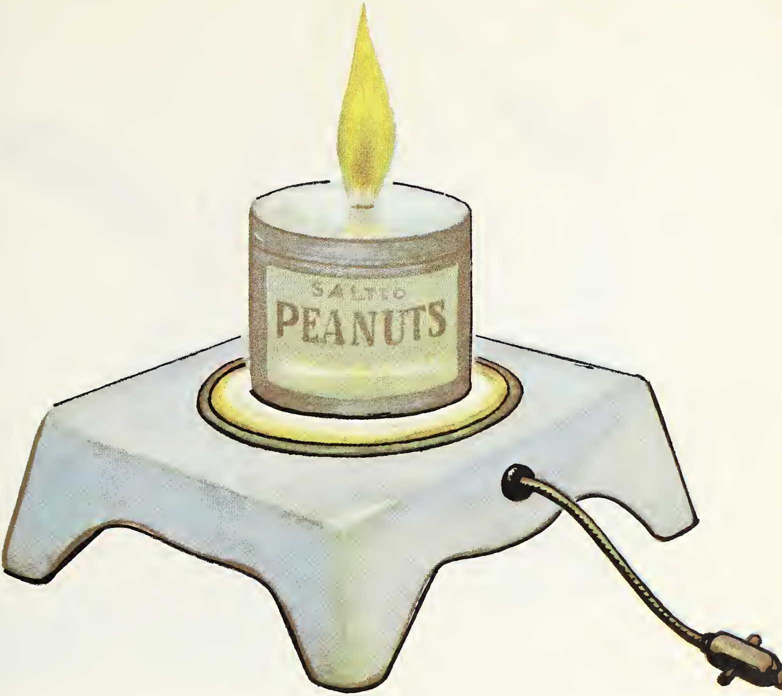


## Wood Flames

Look at the flame of a match. What colours do you see? How is a wood flame like the flame of a candle?

Blow out a match flame. Watch to see if any "smoke" comes from the wood. Does the same thing happen with a candle?

Look at wood fires in a fireplace or in a campfire. What colours do you see in the flames? Where are the colours? Do the flames look like the burning gas of a candle flame?

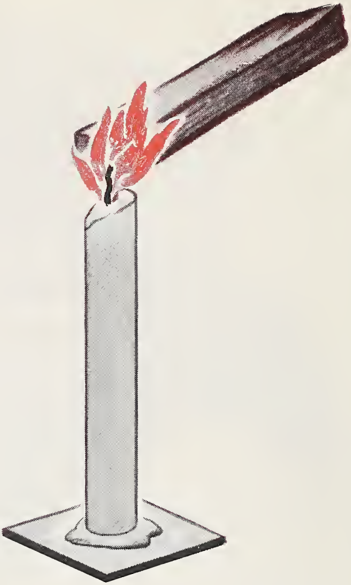


Put a half cupful of wood shavings in a small metal can. Punch a small hole in the lid of the can with a nail. Heat the can.

Does anything come from the hole in the can? What does it look like? What does it smell like? Will it burn?

When wood is heated, part of it changes into a gas. This is the gas that makes the flame when wood burns.

After the gas stops coming from the can, look inside. What is left?

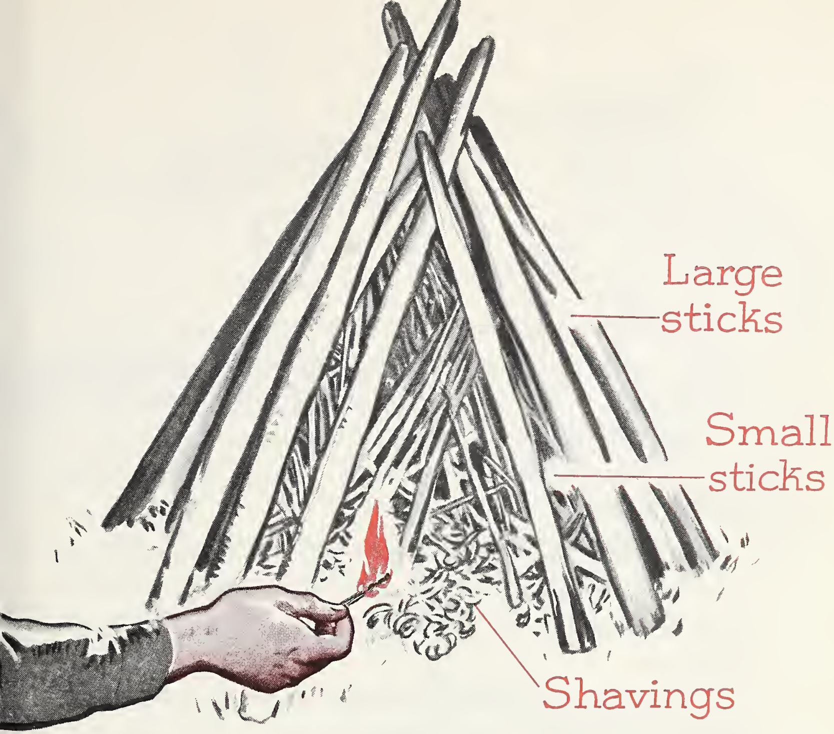


## Starting Wood Fires

Cut two pieces of wood, one very thin and the other thick. Which do you think will start to burn first when held in a flame? Try it.

The thin piece heats up rapidly. It is soon hot enough to give off a gas. Then the gas starts to burn.

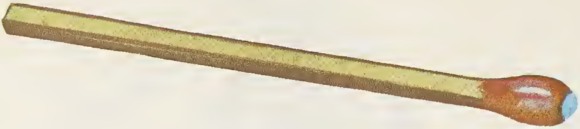
The thick piece of wood does not heat so rapidly. It needs more energy before it gives off a gas.



It is easy to build a wood fire if you know about heat energy. You should be careful to use the right size pieces of wood.

A match does not give off much heat energy. It cannot start large pieces of wood burning. You must use thin pieces of wood when starting the fire.

Thin pieces of wood give off enough energy to start larger pieces burning. Look at the way the campfire at the top of the page is built. Where are the thin pieces? Where are the largest pieces? Can you tell why this is a good way to build a fire?



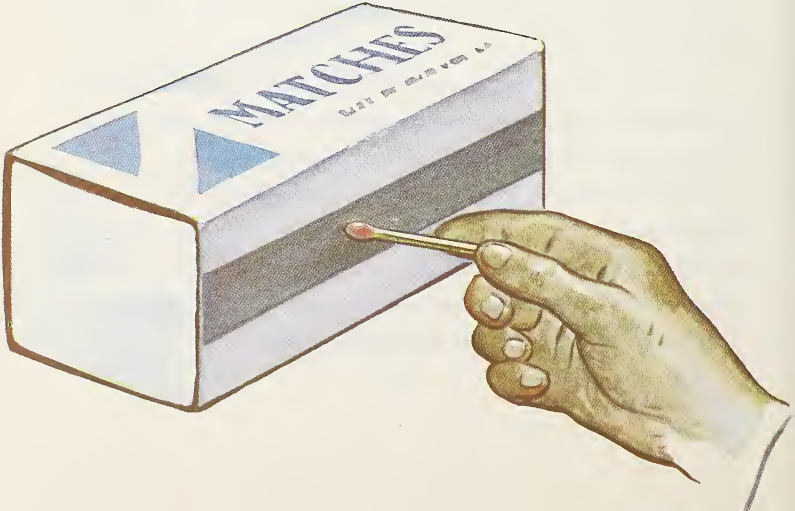
## How a Match Burns

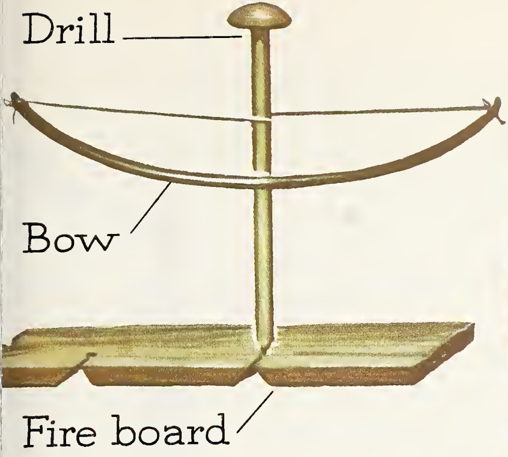
How many parts does this match have? How do you usually start it burning? Can you start it burning any other way?

Light the match. The tip begins to burn first. Which part begins to burn next? Which part begins to burn last?

The energy that lights the match comes from rubbing it. Rub your fingers back and forth rapidly on the cover of this book. Notice how warm your fingers become.

The energy from rubbing starts the end of the match burning. Explain what happens next.

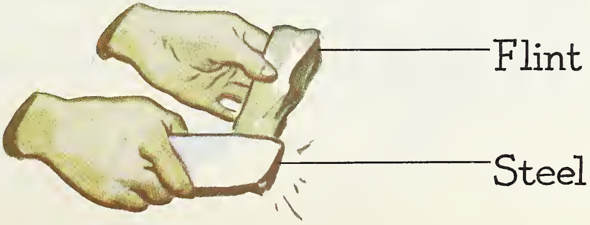




## Fires Without Matches

People today find it easy to build fires because they have matches. Before matches were invented, building fires was not so easy. Much more energy is needed to set fire to pieces of wood than is needed to set fire to the chemicals in the end of a match.

Find out how American Indians built fires before white men came to this country. Find out how the first white men in America built their fires.



## Water and Fire

Cut two pieces of wood of the same size. Soak one piece in water for a few minutes. Now hold both pieces of wood in a candle flame. Which piece starts to burn first?

Hold the wet piece in a flame until it begins to burn. Blow out the flame and look at the wood. Is the wood still wet or is it dry?

As long as the wood is wet it cannot be made hotter than boiling water. This is not hot enough to start the wood burning. Heat energy must be used to evaporate the water before the wood will burn.

You have already learned that fires can be put out by taking away heat energy until they are too cool to burn.

A simple way to cool a fire is to put water on it. This is one of the best ways to put out a campfire.

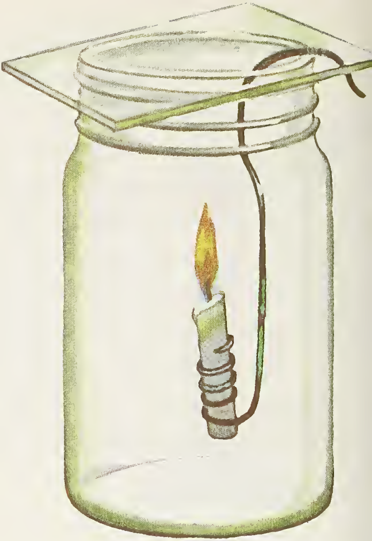
Campfires should be put out carefully so that forest fires do not start. It is best to sprinkle water on the fire until all the wood is wet. Dip your hand in the water and shake it over the fire. Then turn the sticks over and sprinkle them some more.

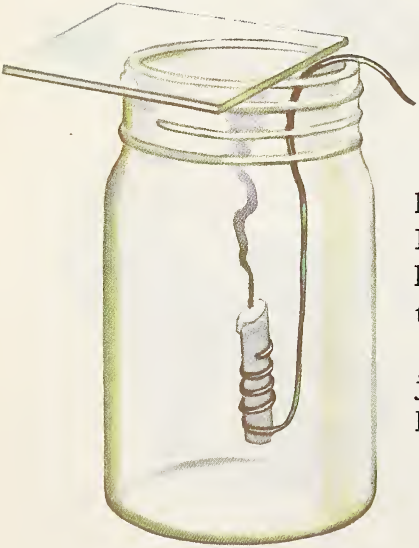
When the fire seems to be out, pour water on the ashes and in a circle all around the ashes. Can you tell why you should do all these things?

## Fire and Oxygen

Fasten a wire to a short candle. Light the candle and lower it into a jar. Put a flat cover on the jar.

What happens?





Slide the cover back a little and lift out the candle. Light the candle again and lower it into the jar. Does the candle keep on burning?

Blow fresh air into the jar. Light the candle and lower it into the jar again.

What happens?

The candle in the closed jar goes out after it has used a part of the air. It cannot keep burning unless it has a fresh supply of air.

Fire needs the part of the air that is called **oxygen.** Oxygen is a gas that you cannot see or smell. It makes up about one-fifth of the air around us.

The candle in the jar burns well as long as there is plenty of oxygen in the air. After it has used up part of the oxygen, the flame goes out. It will not burn again until fresh air has been put in the jar.

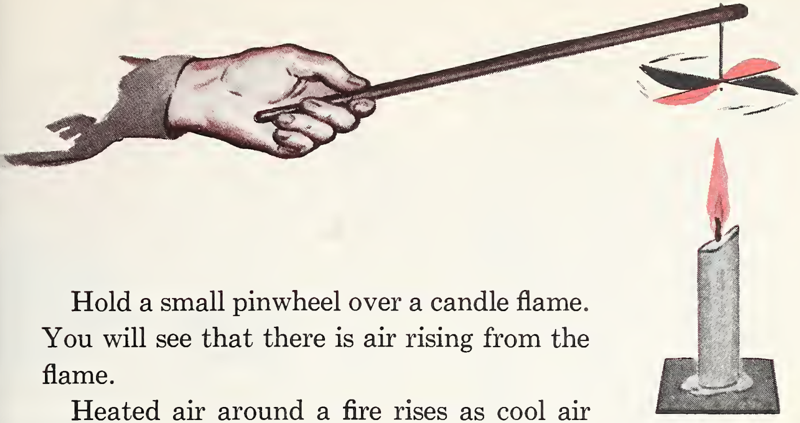
We often put out small fires by keeping fresh air from them. Look at the picture of the cigarette lighter. How is the flame put out?

## Giving Fires More Oxygen

Did you ever make a wood fire burn faster by blowing on it? The fire did not burn well because it had used up part of the oxygen in the air around it. When you blew on the fire you gave it fresh air with plenty of oxygen.

Outdoor fireplaces should face into the wind so that the wind can bring fresh air. Notice how the wind makes the fire burn faster outdoors.

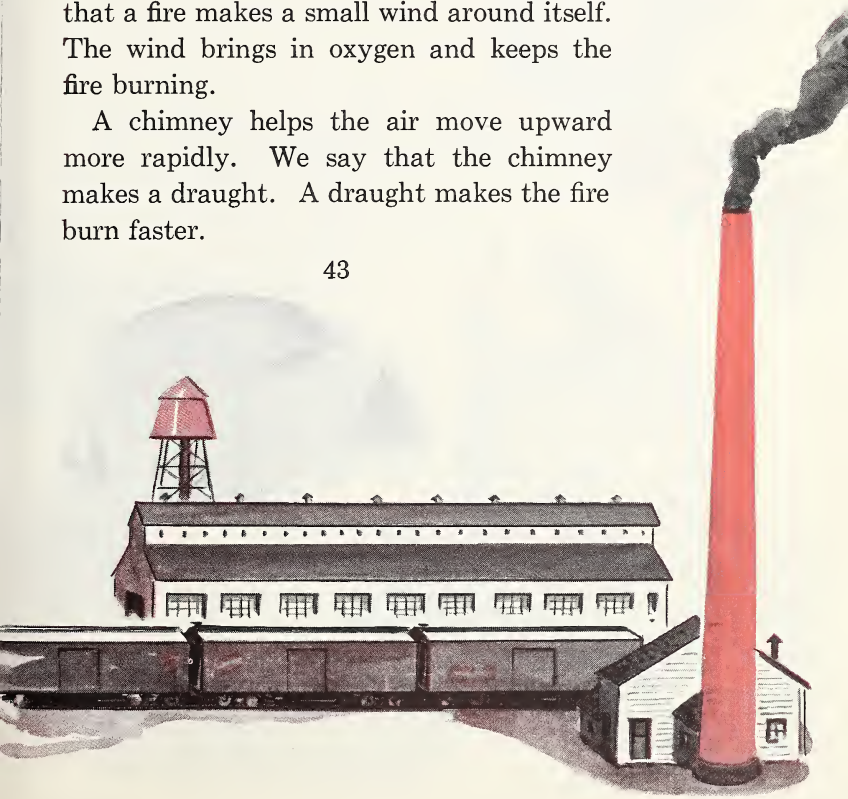
You may use a bellows to blow fresh air on a fire. You can also fan the fire to make it burn faster.



Hold a small pinwheel over a candle flame. You will see that there is air rising from the flame.

Heated air around a fire rises as cool air moves in at the bottom. You might say that a fire makes a small wind around itself. The wind brings in oxygen and keeps the fire burning.

A chimney helps the air move upward more rapidly. We say that the chimney makes a draught. A draught makes the fire burn faster.



## What to Do in Case of Fire

If you find a fire, go to the telephone. Say to the operator, "I want to report a fire." Tell where the fire is. Be sure to give the number of the house and the name of the street. Do not hang up until you have answered all questions that are asked.

Wait until the firemen come. Tell them where the fire is.

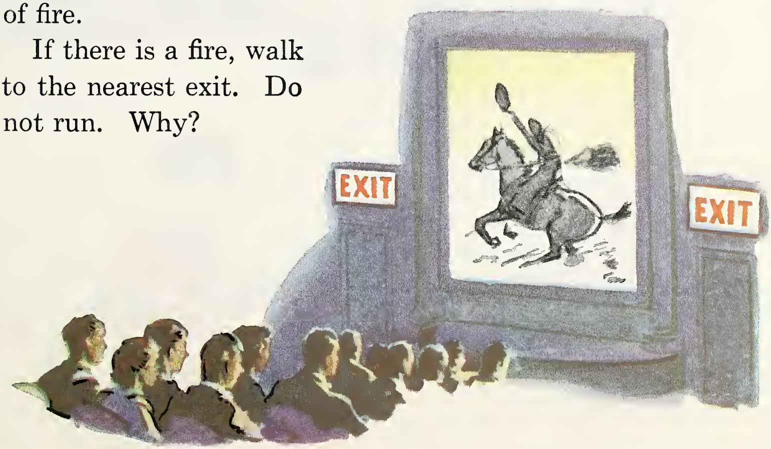
Then stay out of the way. You cannot help the firemen any more. You might get in their way and you might be hurt. Let the firemen put out the fire.

If your clothes catch fire, do not run. Running gives the fire fresh oxygen and makes it burn faster.

Wrap your clothes in a blanket or a rug or some other heavy cloth. Why does the cloth help put out the fire?

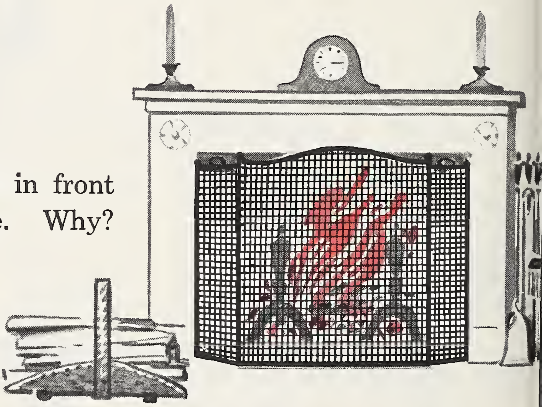
Look for EXIT signs in public buildings such as movie theatres. These signs tell where there are doors that will let you leave the building in case of fire.

If there is a fire, walk to the nearest exit. Do not run. Why?



# Preventing Fires

Have a safe place to burn papers. Why?

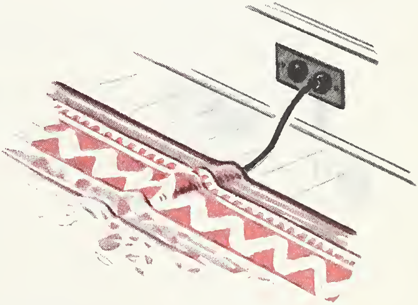


Keep a screen in front of your fireplace. Why?

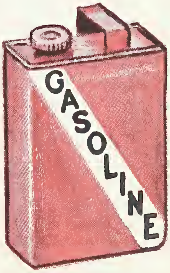
Keep matches away from small children. Why?

Don't keep rubbish around the house. Why?

Don't put a lamp cord under a rug. Why?



Don't keep gasoline in the house. Why?



## Helping Prevent Forest Fires

Forest fires often start because people are careless with campfires. When you start a campfire be sure there are no trees nearby. Dig dead leaves and sod away from the fireplace. Do not build a big fire. Before you leave, put out the fire with plenty of water.

How else can you help prevent forest fires?

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1. What are three things a fire needs in order to burn?
2. What is a flame?
3. How do we start a match burning?
4. Tell how to build and put out a campfire.
5. What are some rules for preventing fires at home?
6. How should you report a fire to the firemen?
7. What do signs that say "EXIT" mean?

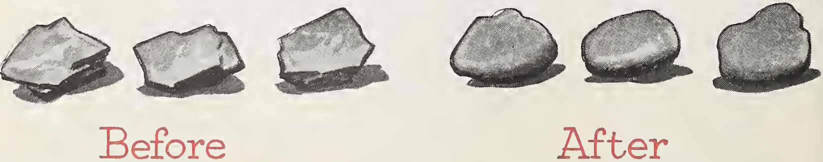
# Streams at Work

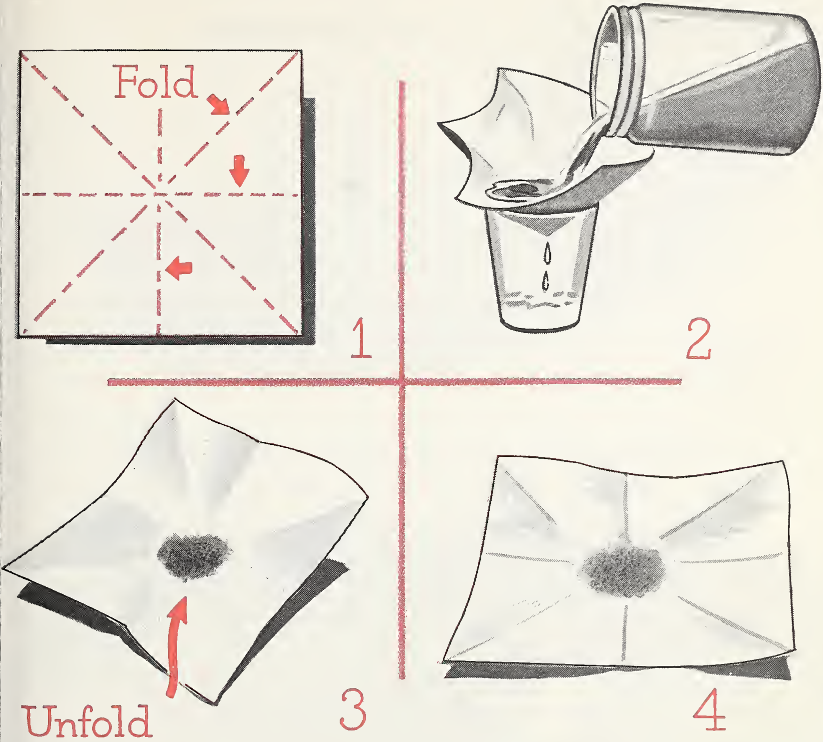
## Moving Water Wears Rocks

Break up a piece of soft rock with a hammer. If you have no soft rock, break up a brick.

Save out some of the pieces of broken rock. Put the others in a glass jar that has a screw top. Fill the jar half full of water and screw on the cap. Shake the jar a hundred times or more.

What happens to the water? What happens to the pieces of rock? Put them beside the pieces that were not shaken in the water. How did they change?





Make a filter from a piece of paper towel as shown in the picture above. Pour the water that was in the jar through the filter.

Is there any change in the water as it goes through the filter? Is anything left on the towel?

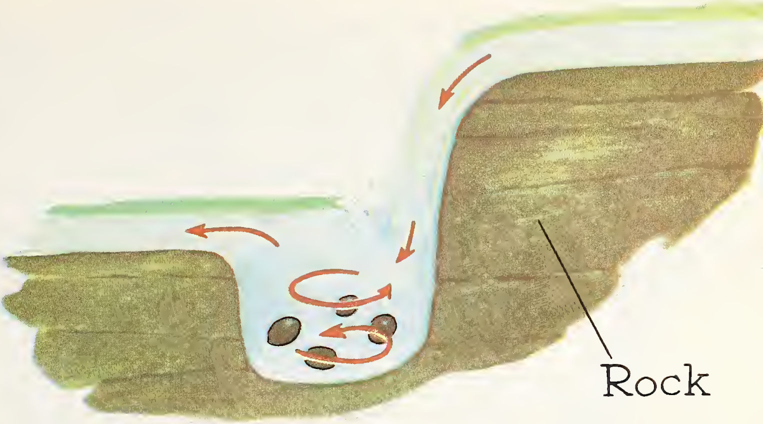
Put the piece of towel in a warm place until the water evaporates. What is left on the paper? Where did it come from?

## Streams Wear Away Their Beds

Swift streams have much energy. They pick up small rocks and hit them against each other. The sharp corners are broken off first.

These small pieces that are broken off also hit against each other and against larger rocks. Slowly the bigger pieces are worn away. They change into soil.

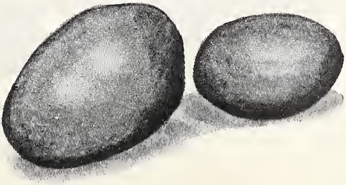
Do you think rocks are worn away faster in hilly country or in level country. Why? Why are they usually worn faster during times of heavy rains?

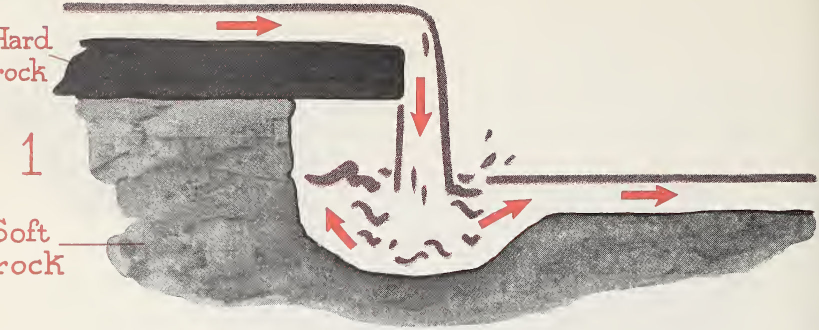


The bits of rock carried by the water also wear away the rock at the bottom of the stream. Every time a small rock hits against the bottom of the stream, a tiny bit of the bottom rock is broken off. As the years go by, the bottom of the stream is worn deeper and deeper.

The bottom of a stream is worn most rapidly at the foot of a waterfall. Study the diagram at the top of the page. Then tell how the hole was made at the foot of the waterfall.

If there is a swift stream nearby, visit it to look for signs that the bottom of the stream is being worn away. Also look for stones that have become almost round as they were carried along by the water.

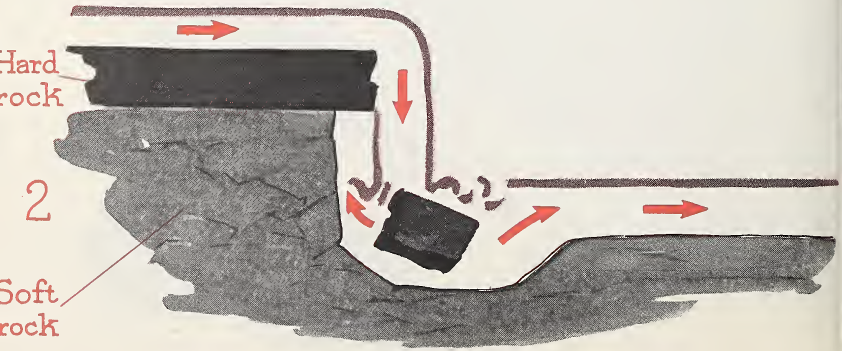


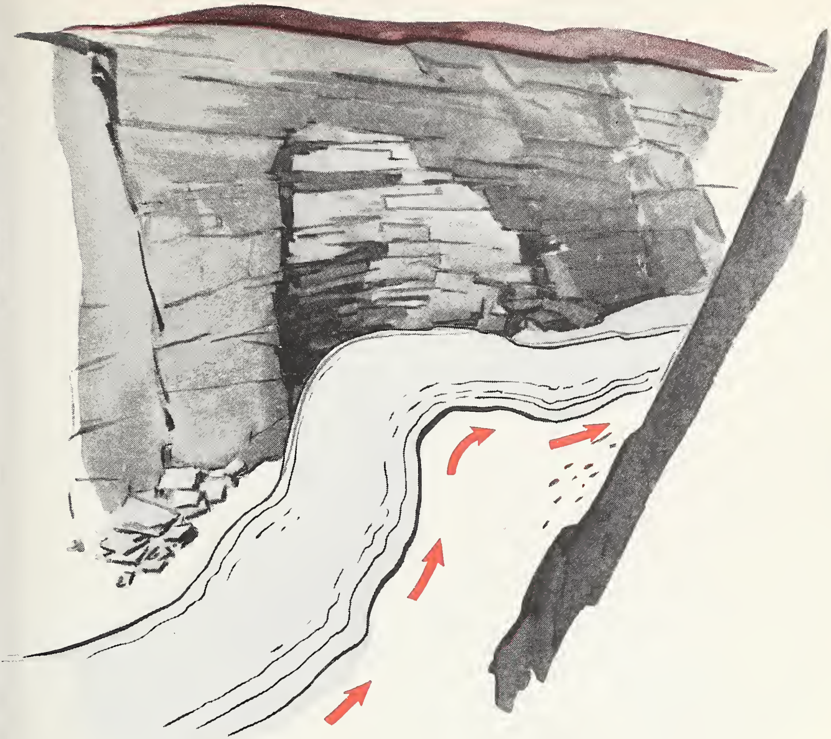


Sometimes there is a layer of hard rock over soft rock. A waterfall can wear away soft rock faster than the hard rock. Pieces of the hard rock then break off when there is nothing underneath to hold them up.

Look at the pictures on this page. Tell the story. Do you think the waterfall will keep cutting back into the rocks? What will probably happen to the pieces of hard rock that fall down into the water beneath the waterfall?

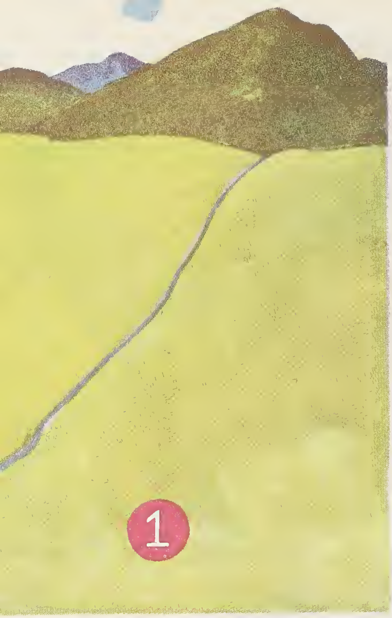
Look at the picture of the waterfall on page 52. This waterfall is cutting back into the hill. Have you ever seen a waterfall like this? Where?

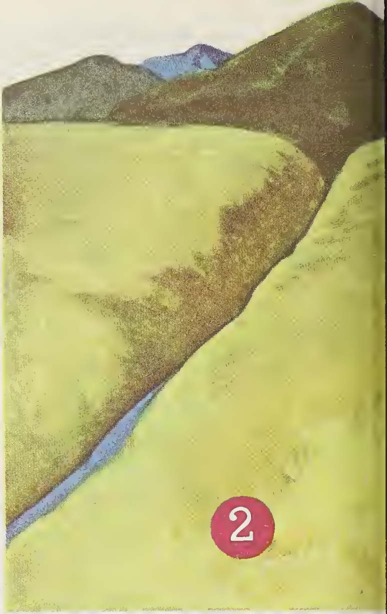




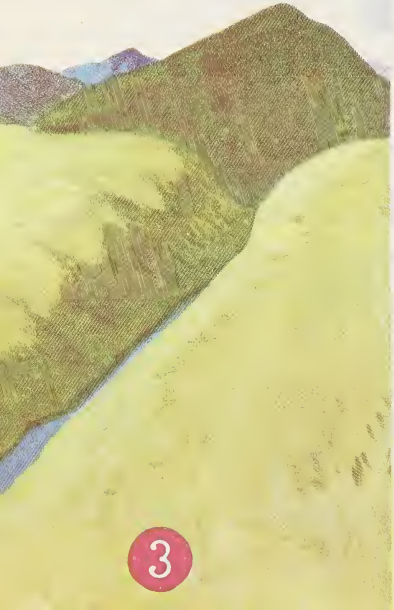
Streams make valleys wider as well as deeper. In this picture we are looking down on a stream that is winding back and forth along a valley. The stream is cutting away the bank where it touches the side of the valley. Have you ever seen places where a stream is cutting away a bank like this? Where?

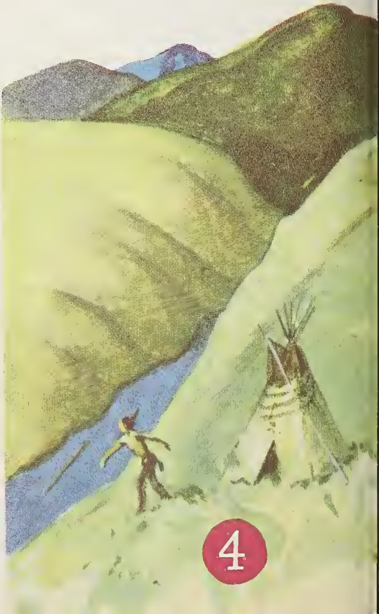
The stream may change its path after a time. Then it will cut away the banks in new places. Slowly the valley is made wider.

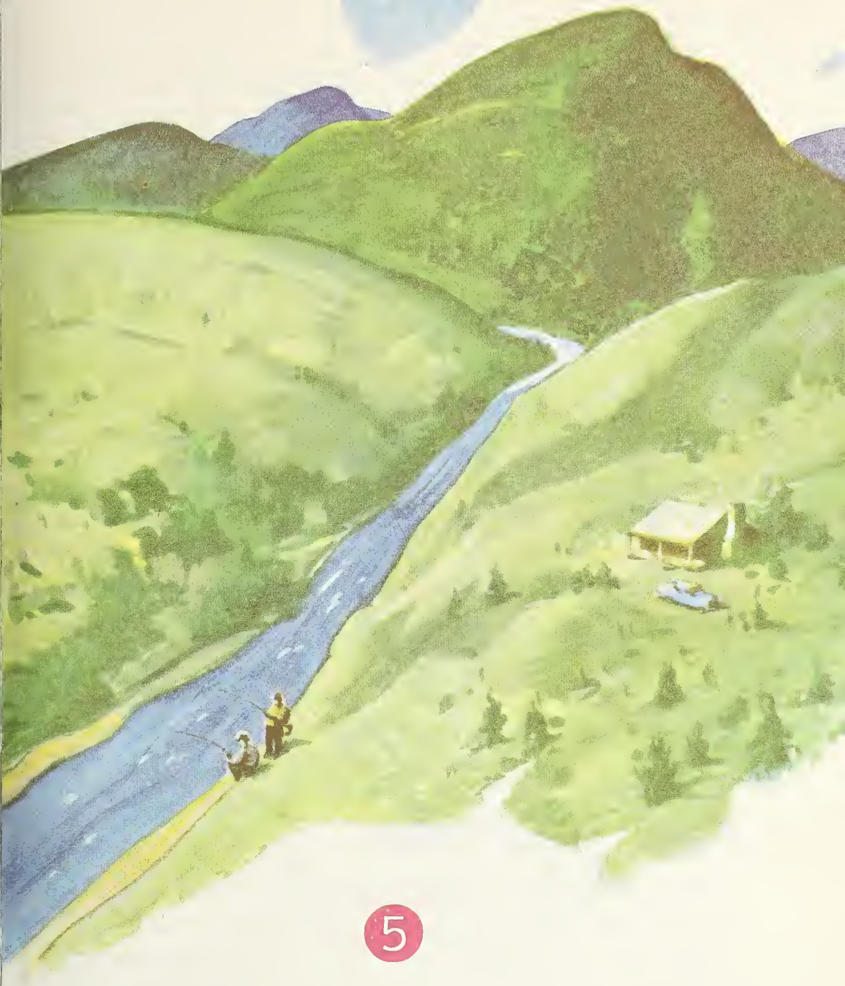




**A Stream Makes a Valley**







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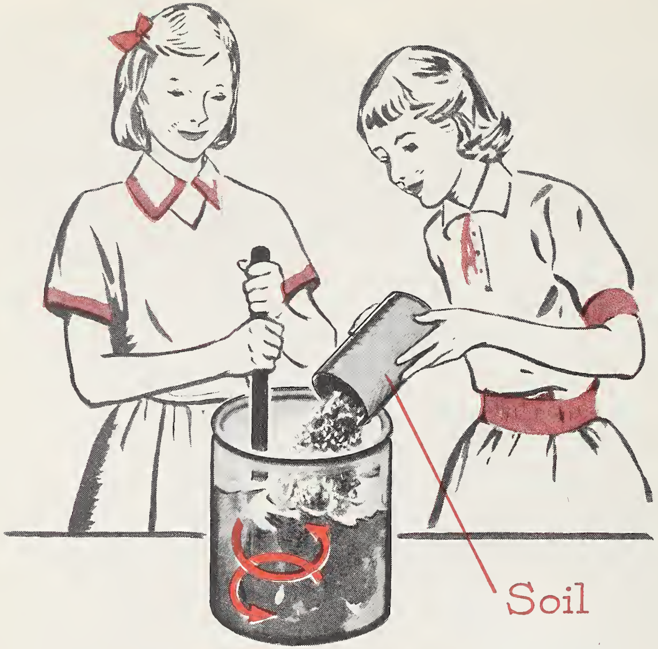
Water has bumped and rolled stones down this stream for many years. A deep valley has been worn in the rock. The rocks and the soil that were worn from the valley have been carried away by the stream.

Are there valleys like this near your home?



## Soil in Moving Water

Put some water in a glass jar. Stir the water with a stick to make it move rapidly. Then pour in some soil.

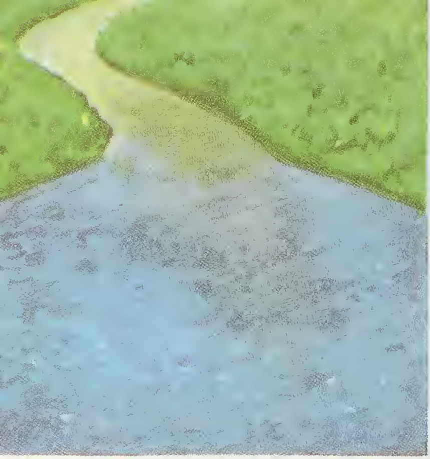
What happens while the water is moving? What happens as the water slows down? What happens when the water stops?

There are places where swift streams slow down. They slow down when they come to flat land. They slow down when they flow into lakes or oceans. What do you think happens to the soil in the water?

Wait until the water in the jar has stopped moving. Then look at the soil. Notice that the largest pieces are at the bottom. They must have dropped first. Then smaller pieces were dropped as the water slowed down a little more. What kind of soil dropped last?

The same thing happens in streams. The largest rocks drop first as the water begins to slow down. Then smaller pieces are dropped. The mud drops when the water has stopped moving.

Visit a stream. Look for large stones, sand, and mud. Has the stream dropped these different sizes together, or has it dropped them in different places? If there is no stream near your school, look at a pile of soil after a rainstorm.



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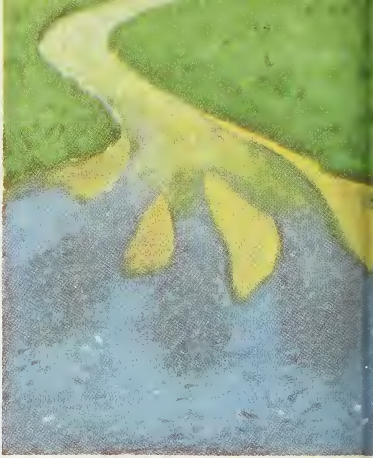

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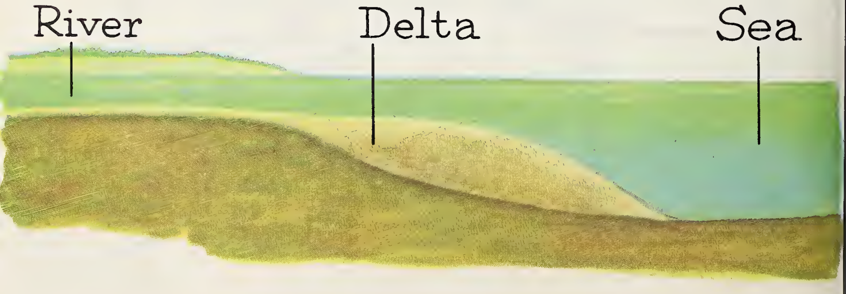
## Deltas

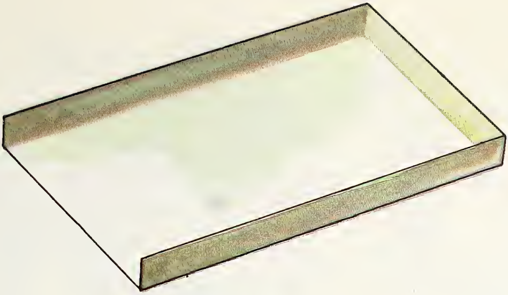
The first picture above shows a stream flowing into a lake. The second picture shows the same place many years later. What has happened?

New land that is made this way is called a **delta.** Where did it come from?

See if you can find a delta where a stream flows into a lake or pond.

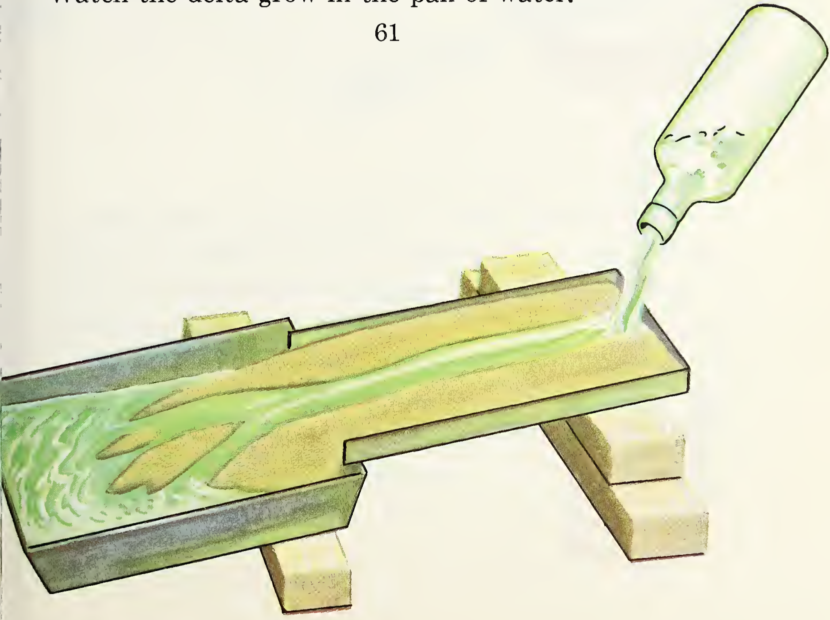
Look at maps that show where rivers flow into seas or oceans. Can you find any deltas?



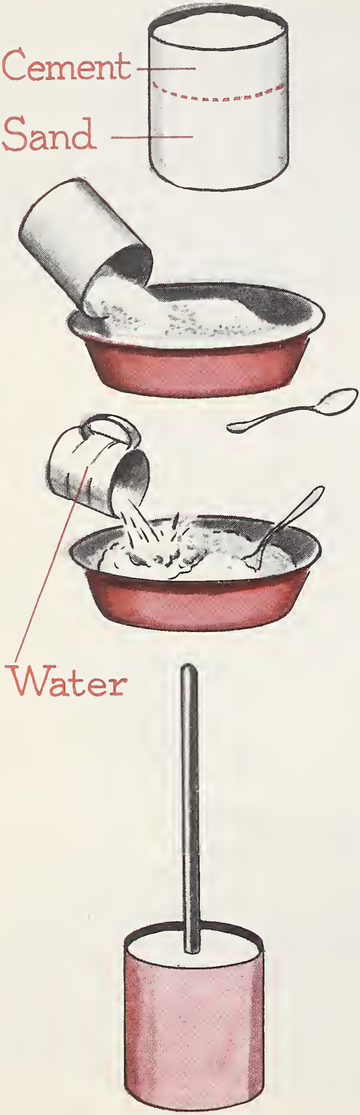


You can make a delta in a pan of water. You will need a tray like the one above. You can make the tray from wood or from metal, or you can cut out one end of an old tray or cake pan.

Fill the tray with sand. Set the tray on a pan of water as shown in the picture below. Pour water very slowly on the sand to make a small stream of water. Watch the delta grow in the pan of water.



# Making a Rock



Fill a can about two-thirds full of sand. Then put in enough cement to fill the can to the top.

Pour the sand and the cement into an old pan. Mix them with an old spoon.

Add water slowly and keep stirring until the mixture is like thick mud.

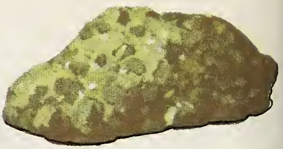
You may pour the mixture into a can and push a round stick into the mixture as shown at the left. When the mixture is nearly hard, take out the round stick. You may then use the block as a flagpole holder.

Most sidewalks are made like the rock you just made. Cement, gravel, sand, and water are mixed together. Then the mixture is poured into a form. Soon it hardens into a rock. The rock is called concrete.

What are some other things that are made of concrete? List as many as you can.

Perhaps you can see some concrete being made. Watch what is done.

Gravel



Conglomerate

## How Some Kinds of Rocks Are Made

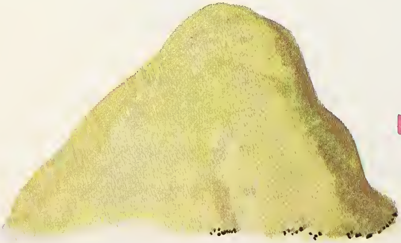
Gravel that is buried deep may be cemented together by a natural cement. This cement is brought by the water that runs through the soil.

A rock made of gravel cemented together is called **conglomerate.** The rock is sometimes called "pudding stone" because it looks a little like some kinds of pudding.

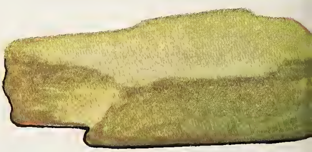
Sand may be cemented together the same way. The rock that is formed in this way is called **sandstone.** Sandstone is more common than conglomerate.

Look at a piece of sandstone with a hand lens. Can you see the grains of sand in it?

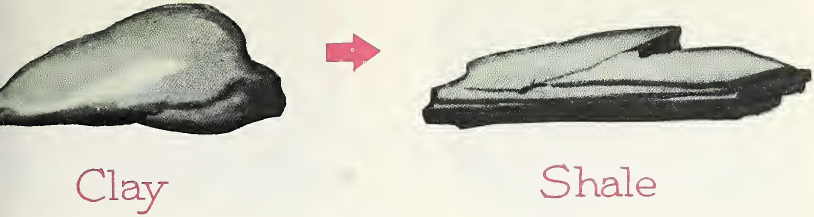
Sandstone is often used in buildings. Try to find some sandstone in a building.



Sand



Sandstone

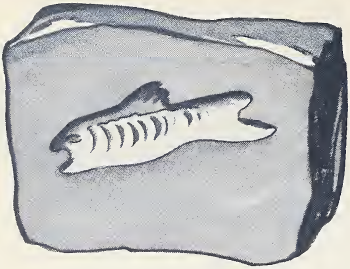


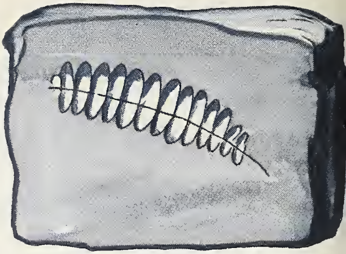
Clay is dropped in quiet water. It may be packed together and cemented after it has been buried a long time. The rock that is formed is called **shale.**

If you have some clay, breathe on it and then smell it. Notice its smell. Then breathe on a piece of shale. You will notice the same smell because it is made of clay.

Large numbers of shells of clams and other water animals are often buried and cemented together. The rock that is formed is called **limestone.**

Make a collection of these different kinds of rocks.



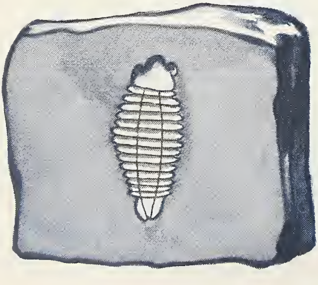


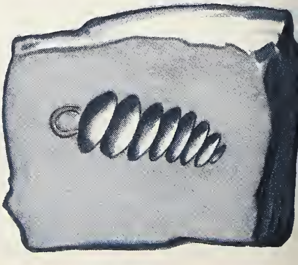
## Fossils

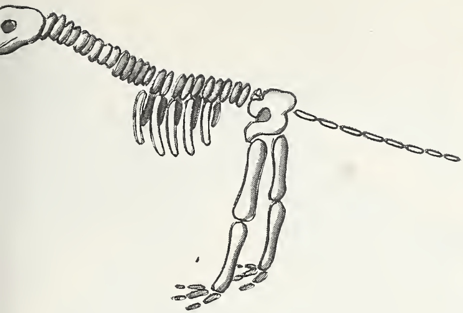
Dead plants and animals are sometimes buried deep in mud and sand. If the mud and the sand are changed to rock, prints of the plants and animals are left in the rock.

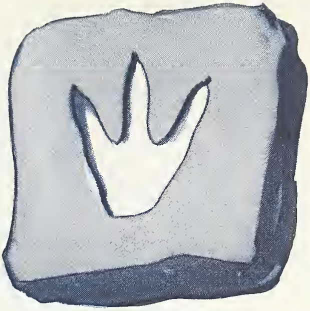
Prints such as these are called **fossils.** They are often found in sandstone, shale, and limestone. They tell us that there were living things on the earth many, many years ago.

If you live where there are fossils in the rocks, make a collection of them.



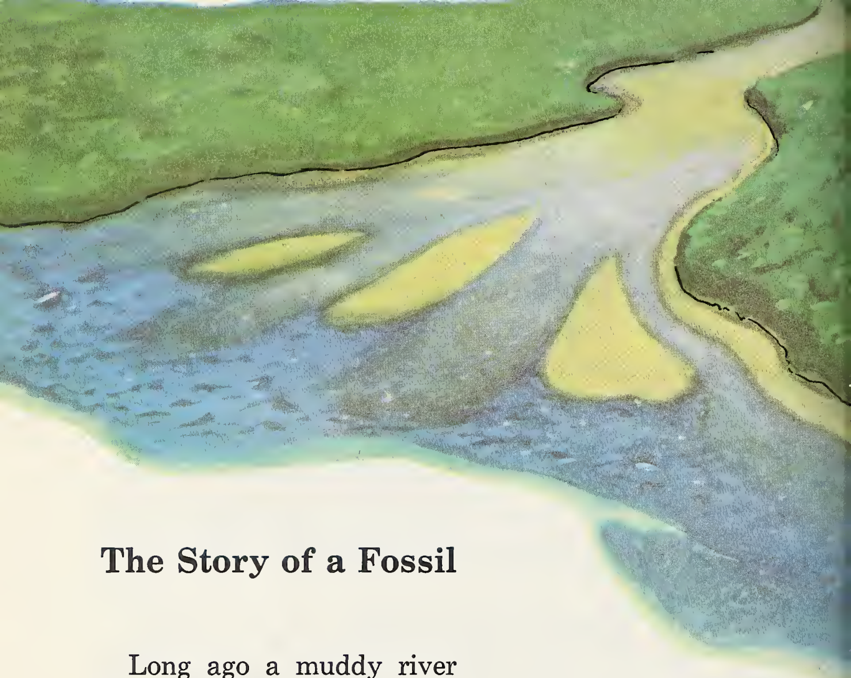






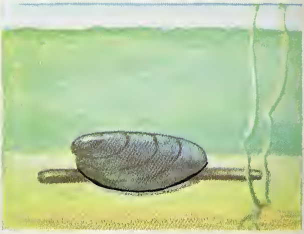
Fossils tell us about the plants and animals that once lived on the earth. We know that there have been great changes in the kinds of living things. Most of the kinds that lived on the earth long ago are gone now. New kinds have taken their places.

By studying bones and footprints, we are able to guess what some of the large animals looked like. By studying prints of leaves and bark, we can guess what some of the plants looked like. Perhaps you can find pictures that show what we think some of the living things of long ago looked like.

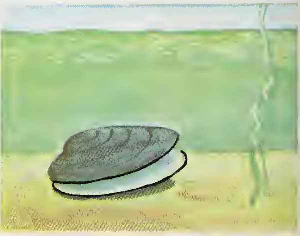


# The Story of a Fossil

Long ago a muddy river flowed into the ocean.



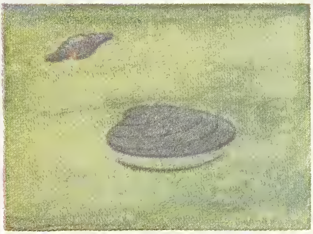
A clam lived in the water at the mouth of the river.



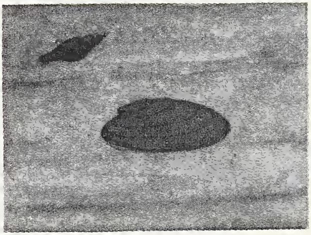
The clam died. Its shell lay in the mud.

Mud from the river slowly covered the clam shell.

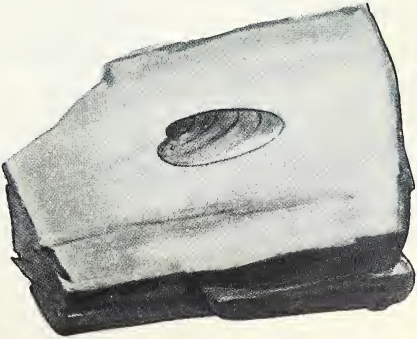
More and more mud fell on top of the shell. After many years it was buried deep below the water.



As more years went by, the mud was changed to rock. The shell dissolved away.



One day a boy was walking along the river. He found a piece of rock with the print of the clam shell in it.



In some parts of the world there are streams of ice called **glaciers.** These streams of ice flow very slowly. As they flow, they dig out their beds somewhat as streams of water do. When glaciers melt, they drop in piles those bits of rock which they dug from their beds.

1. How does a stream wear away a rock?
2. How are valleys often formed?
3. How is a delta formed?
4. How is concrete made?
5. How is sandstone made?
6. What are fossils?

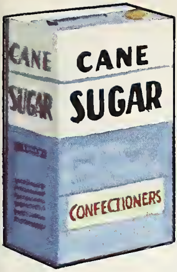
# Sugar and Starch

## Sugar for Cooking

There is sugar in many foods. Perhaps you have seen your mother put sugar in pies, cakes, and cookies. You will be surprised to learn of the many other foods that have sugar in them.

Bring some cookbooks to school and look for foods that have sugar in them. Is there sugar in bread and biscuits? Is there sugar in pickles? Can you find any cakes or cookies that are made without sugar?

Make a list of foods that have sugar in them.



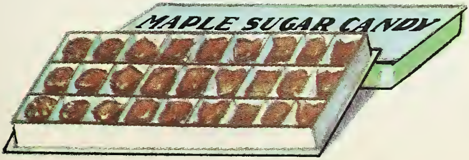
## Kinds of Sugar

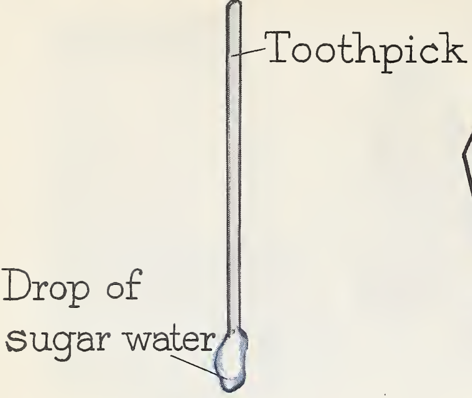
You may have seen your mother use brown sugar, white sugar, powdered sugar, and molasses. These are all made from the sap of sugar cane.

First, most of the water in the sap is evaporated. The sugar forms into brown crystals. The part that is left is molasses.

The brown crystals are brown sugar. The colour is taken out of the brown sugar to make white sugar. Taste both brown sugar and white sugar. Was the taste changed when the colour was changed?

Sugar is also made from the sap of sugar beets. Do you know of any other kinds of sugar?





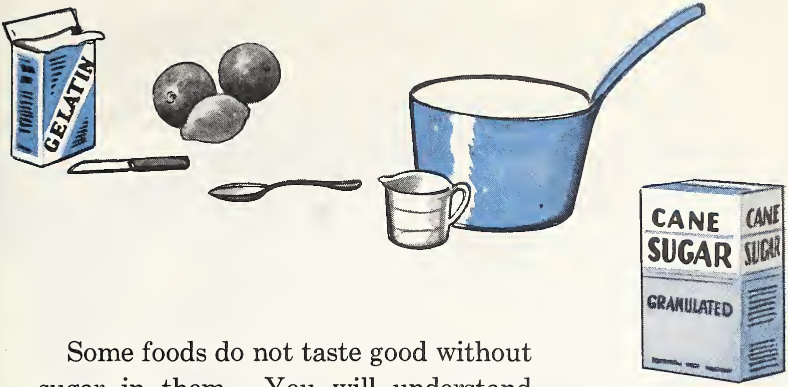
## Tasting Sugar

We can find out whether there is sugar in foods by their taste. Almost everything that tastes sweet has sugar in it.

Try to find the part of your mouth that tastes the sugar. Dip a toothpick in a mixture of sugar and water and touch it to the tip of your tongue. Does it taste sweet? Touch the toothpick to other parts of your tongue. Can you taste sugar with all parts of your tongue?

Can you taste sugar with your lips? Can you taste it with the top of your mouth?

Taste some honey. Do you think there is sugar in it? Taste some corn syrup. Is there sugar in corn syrup?



Some foods do not taste good without sugar in them. You will understand this if you make a dessert without sugar in it.

Mix one tablespoonful of gelatin with half a cup of cold water. Mix this with half a cup of hot water. Add half a cup of orange juice and a tablespoonful of lemon juice.

Pour half of this into a dish. Add one-fourth of a cup of sugar to the rest of the dessert and pour it into another dish. Set both dishes in a cool place until the gelatin is hard.

Taste each one. Which tastes better?

# Foods with Natural Sugar

Many foods grow with sugar in them. We do not need to add sugar to them to make them taste sweet.

Green peas and corn are two foods that grow with sugar in them. Some kinds of corn have so much sugar in them that they are called "sweet corn."

Ripe fruits have sugar, too. Ripe strawberries, pears, and apples are very sweet.

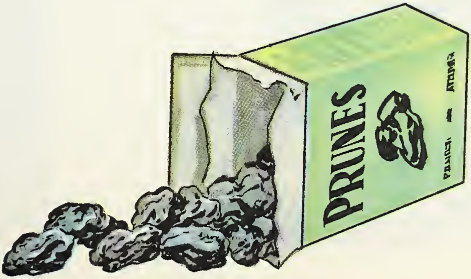
Sugar forms in these fruits as they ripen. They may change their colours at the same time. What are the colours of some common fruits before and after they are ripe?

Some fruits make good dried fruits because they have so much sugar in them. Sugar keeps dried fruits from spoiling.

Raisins are made from certain kinds of very sweet grapes. The ripe grapes are picked and put in sunlight. Heat from the sunlight evaporates the water from the grapes.

Put some raisins in water. They will soak up water and become almost as large as they were before they were dried.

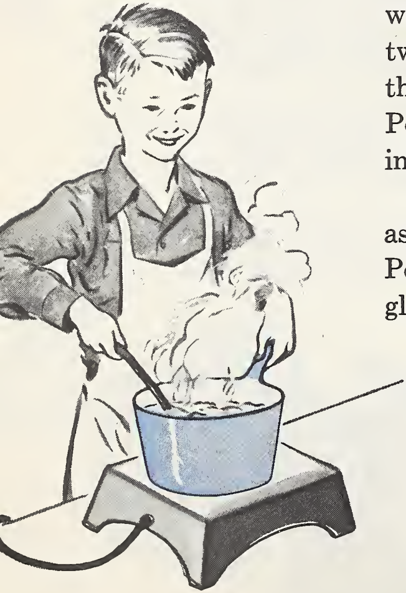
Read about prunes and see what they are made from. Make a list of other kinds of dried fruits.



## Sugar to Keep Foods from Spoiling

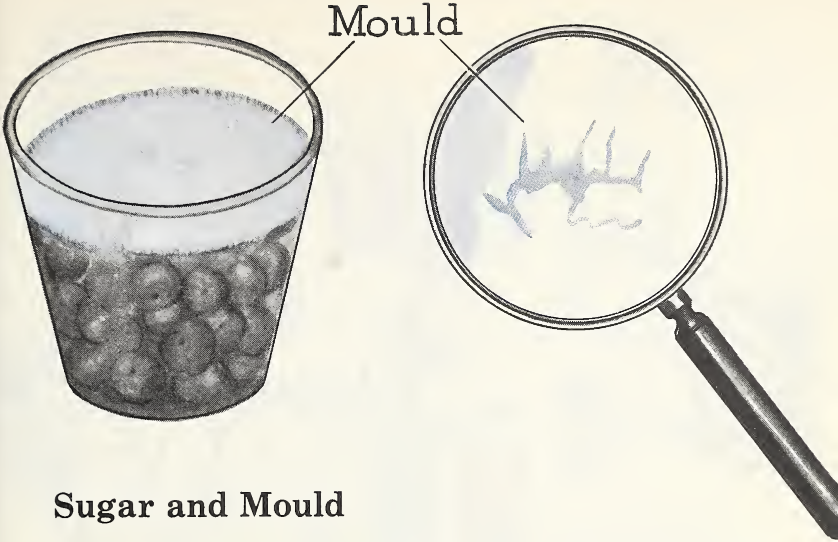
Many kinds of bacteria and other tiny plants can live in our foods. They spoil the taste of the foods and sometimes give off poisons that make us sick.

Most of these tiny plants cannot live in a thick sugar syrup. We can keep many fruits from spoiling by putting them in thick syrup or by making them into jam.



Mix some fruit with an equal weight of sugar. Let it stand two or three hours. Then boil the mixture until it is thick. Pour the jam you have made into a clean glass.

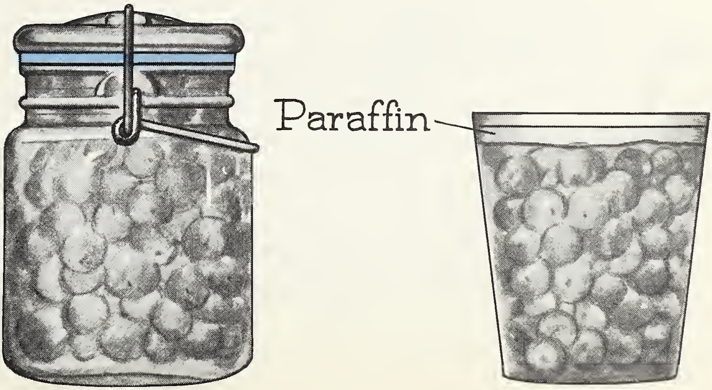
Boil some fruit without sugar as long as you boiled the jam. Pour this into another clean glass. Which keeps better?



## Sugar and Mould

After jam stands a few weeks a tiny plant may grow on it. This plant is called **mould.** Mould uses the sugar in the jam for food. In time it may spoil the taste of the jam.

You can keep mould away from jam by pouring melted paraffin on the jam. You can also put the jam in a clean jar that has a tight cover. Perhaps you would like to try both ways.



## Testing for Starch

Many foods have starch in them. Perhaps you have eaten cornstarch pudding. It is made with starch. Do you know of other foods made with cornstarch in them?

You can find out whether there is starch in food by testing it with iodine. Mix a little cornstarch in a glass of water. Put water in another glass. Add a drop of iodine to each glass.

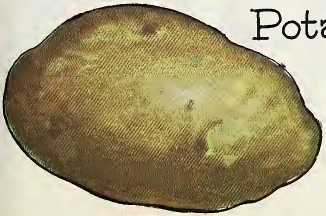
What colour did the starch become when you put iodine on it? Did the colour change in the other glass?

Test different kinds of food for starch. Test a piece of bread first. Soak the bread in water. Put a drop of iodine on it. Does the bread become the same colour as the cornstarch? If it does, it has starch in it.

Scrape off a bit of apple and mix it with water. Add a drop of iodine. Does the apple have starch in it?

Test many different foods. You may be surprised at the number that have starch in them.

Most of the starch you eat comes from two plants, potatoes and wheat. At what meals do you eat potatoes? At what meals do you eat foods made of wheat flour?

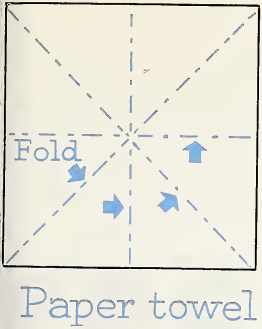


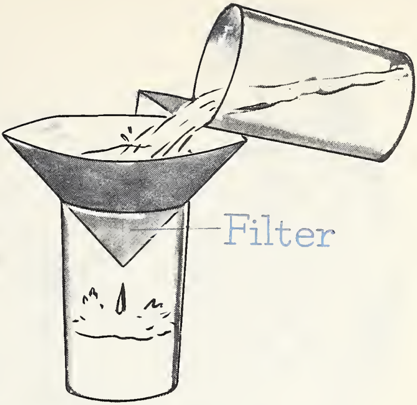
## Dissolving Starch and Sugar

You probably know already that sugar dissolves easily in water. This makes it a useful food. It dissolves in blood and can be carried to the muscles of animals where it is used. It dissolves in sap and can be carried to the parts of plants where it is used.

Starch is also a common food. Let us find out whether it dissolves in water, too.

Put a teaspoonful of starch in a glass of water and stir it. Put a teaspoonful of sugar in another glass of water and stir it. Look at the two glasses. Did the sugar seem to dissolve? Did the starch seem to dissolve?

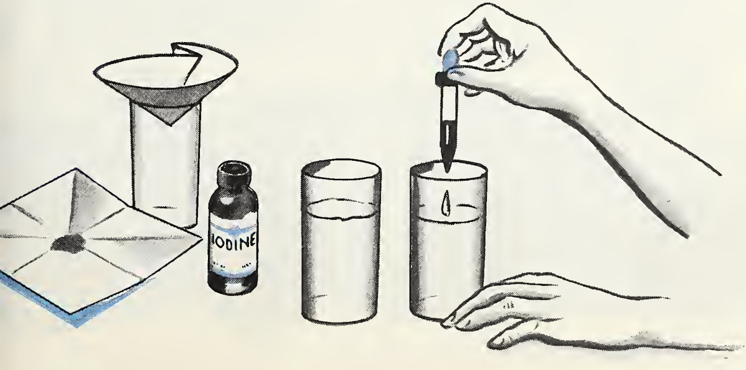




Make a filter from a piece of paper towel as shown in the picture above. Pour some of the sugar water through the filter. Taste the water that goes through the filter. Did some of the sugar go through the filter?

Make another filter. Pour some of the starch and water mixture through the filter. How does the water that went through the filter look? Add a drop of iodine to this water. Did any starch go through the filter?

Only things that dissolve can go through a filter. Did the sugar dissolve? Did the starch dissolve?

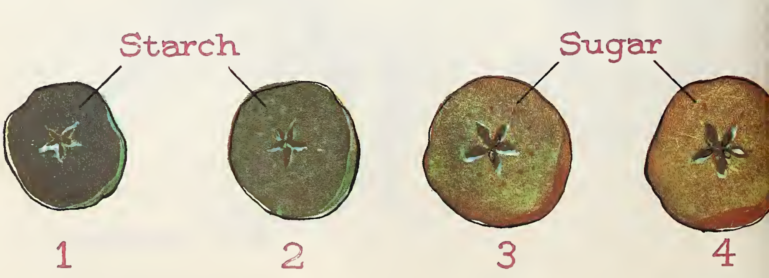


## Sugar and Starch in Plants

Plants are able to change starch into sugar. Green fruits usually have starch in them. The starch changes to sugar as the fruits become ripe.

Find some green apples, some ripe apples, and some apples that are partly ripe. Cut the apples in half. Put iodine on each apple. Is there starch in the apples? Where? Which apples have the most starch?

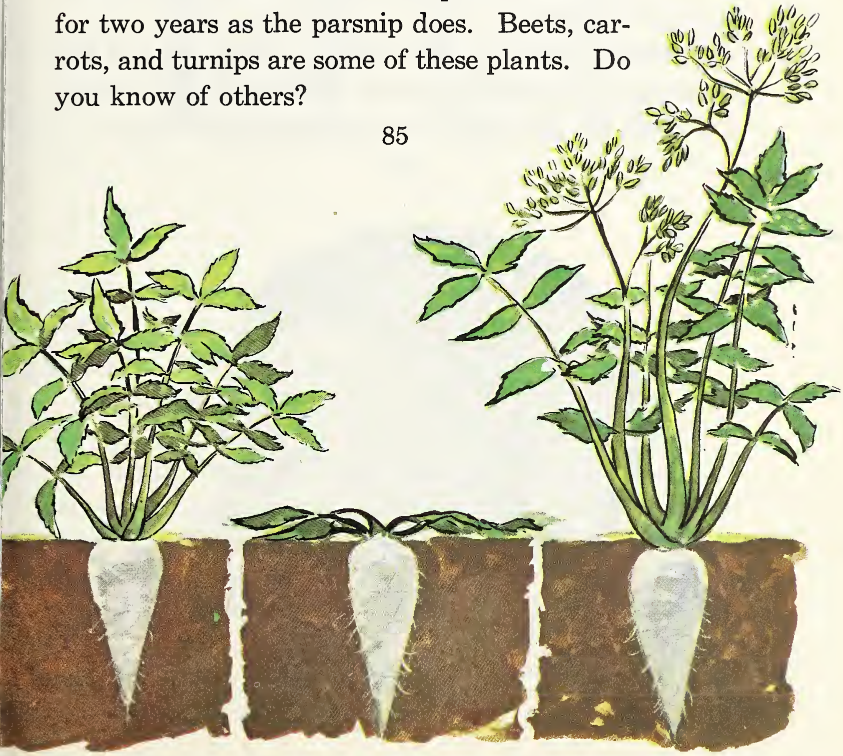
The apples in the picture below have been tested with iodine. The greenest apple is at the left.



Plants with starch stored in their roots change it into sugar before they use it. Perhaps you have eaten parsnips in the fall. They are filled with starch and have little taste. By spring they become very sweet.

A parsnip plant stores starch in the root during the first summer of its life. In late winter, the starch in the root begins to change to sugar. When spring comes, sap carries the sugar up to the stems and leaves. The plant uses the food to make flowers, leaves and seeds. After the seeds are ripe, the plant dies.

There are a number of other plants that live for two years as the parsnip does. Beets, carrots, and turnips are some of these plants. Do you know of others?



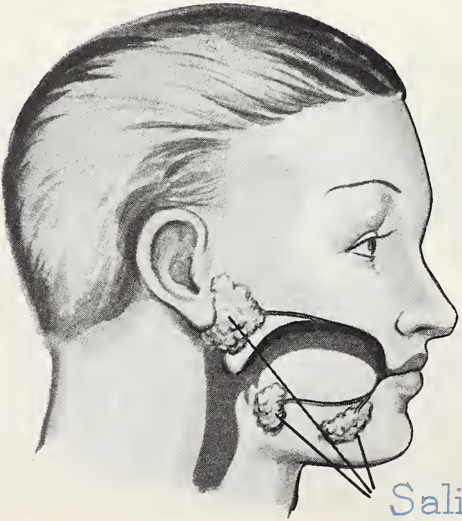
## Digesting Starch

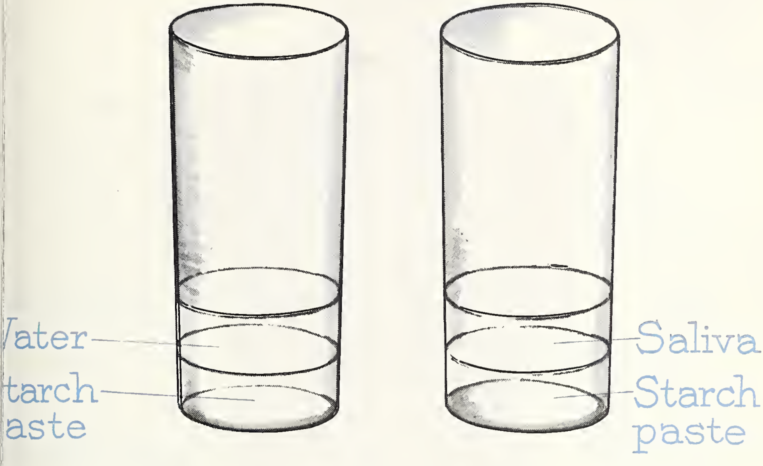
You have seen that sugar dissolves in water but that starch does not. The sugar we eat dissolves in water and can be carried by our blood through our bodies.

We cannot use starch the same way. We must first change it to something that will dissolve. We make this change by digesting it.

Chew a bit of cracker and hold it in your mouth for one minute. Notice that the cracker begins to taste sweet. The starch is beginning to change to sugar as you hold it there.

Digestion begins in the mouth. Glands around the mouth give out **saliva** that is mixed with the food as you chew it. The saliva changes starch into sugar.



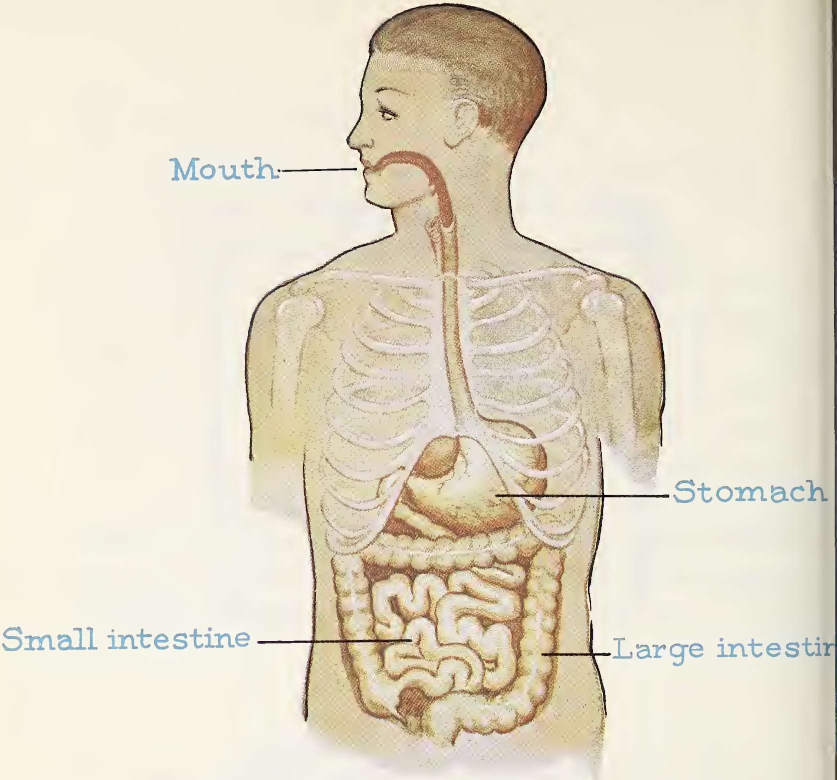


Mix a tablespoonful of cornstarch with a cup of water. Heat this until it boils and then cook it for ten minutes. Stir it so that it does not burn.

Put a teaspoonful of the cornstarch paste in each of two glasses. Put a teaspoonful of saliva on the paste in one glass. Put a teaspoonful of water on the paste in the other glass.

Set the two glasses in a warm place for an hour. Then look at them.

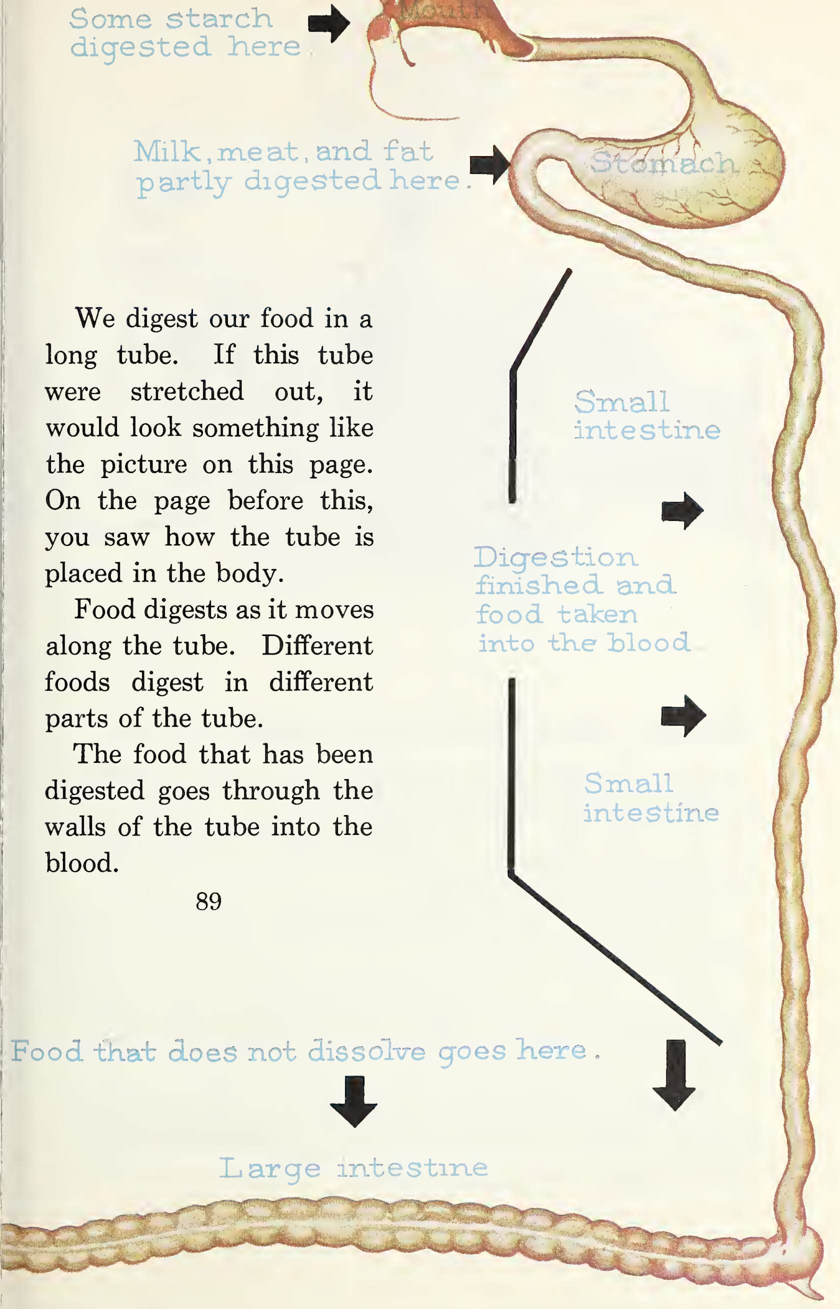
The paste in the one glass will dissolve if saliva changes starch into sugar. The paste in the other glass should not be changed.



## Digesting Foods

There are many foods such as starch that will not dissolve in water. They cannot be taken into the blood until they are changed.

Some foods digest more slowly than others. Some will not dissolve until they have been digested for several hours. This picture shows where our food is digested.


Some starch digested here
Mouth
Milk, meat, and fat partly digested here.
Stomach
Small intestine
Digestion finished and food taken into the blood
Small intestine
Food that does not dissolve goes here.
Large intestine

We digest our food in a long tube. If this tube were stretched out, it would look something like the picture on this page. On the page before this, you saw how the tube is placed in the body.

Food digests as it moves along the tube. Different foods digest in different parts of the tube.

The food that has been digested goes through the walls of the tube into the blood.

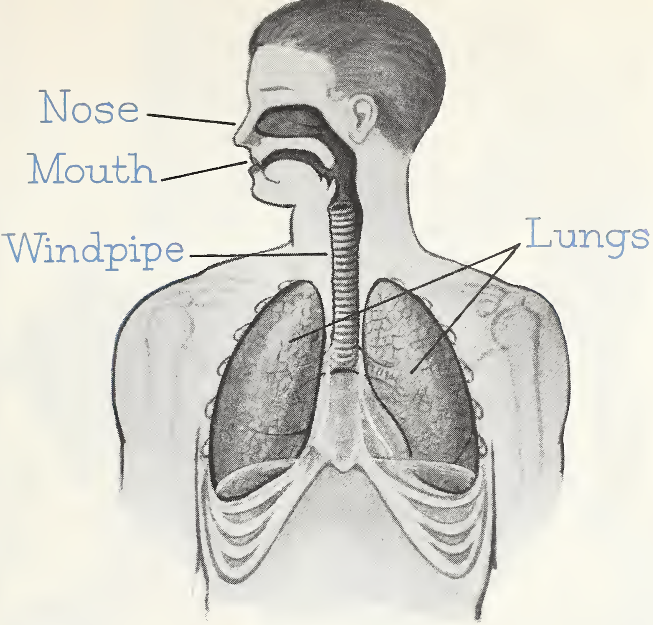
## Energy from Starch and Sugar

Lay a card across the open end of a small metal can. Put half a teaspoonful of sugar on the card and set fire to the card. Soon the sugar will seem to boil and then it will burn with a blue flame.

Lay another card on the can and try to burn cornstarch the same way.

We see from this experiment that both sugar and starch have energy. They give off energy when they burn.

The sugar and starch we eat give us part of their energy. We need the energy to keep our bodies warm and to make our muscles move.



You have already learned that fuels need oxygen in order to burn. They cannot give off their energy without oxygen. Sugar and starch also need oxygen in order to give off their energy.

We take oxygen into our bodies when we breathe air into our lungs. Oxygen passes through the walls of the lungs into the blood. Then it goes to the muscles and other places where the food is used.

The food takes up the oxygen slowly and gives off energy. Some of the energy warms our bodies. Some of the energy is used by our muscles when we move.

When we run we breathe rapidly. How does this help us?

## Animals Store Food

Both plants and animals store food in their bodies. Animals store food as fat.

This pig is eating corn. The pig will change the starch in the corn to sugar. It will use some of the sugar for energy. It will change the rest of the sugar to fat and store it.

---

1. What are some plants that have sugar in them?
2. Why must we digest starch before we can use it in our bodies?
3. What are some foods that have starch in them?
4. What do we get from sugar and starch?
5. How can we tell when there is starch in a food?
6. How do plants use starch stored in their roots?
7. In what part of our bodies do we digest food?

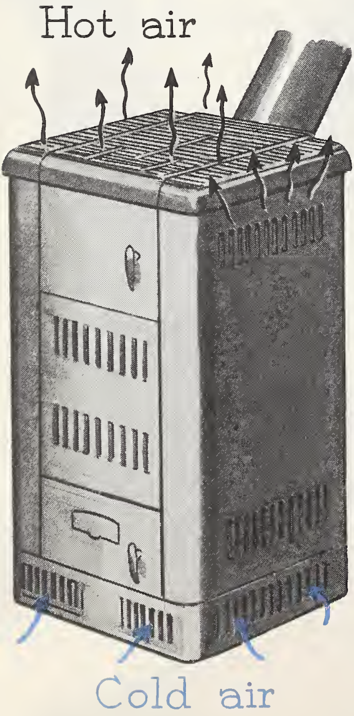
# Warm Weather Indoors

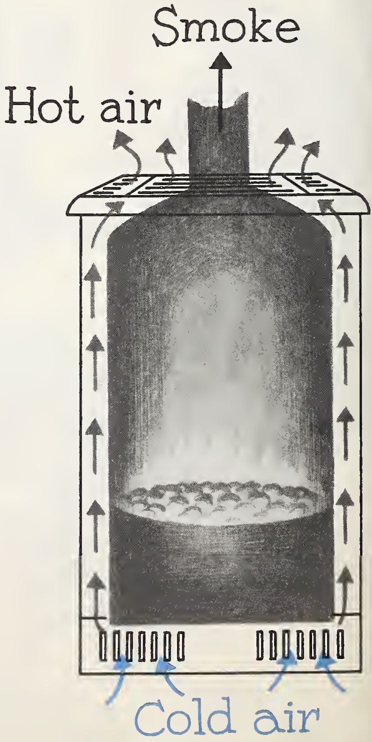
## Hot Air Heating

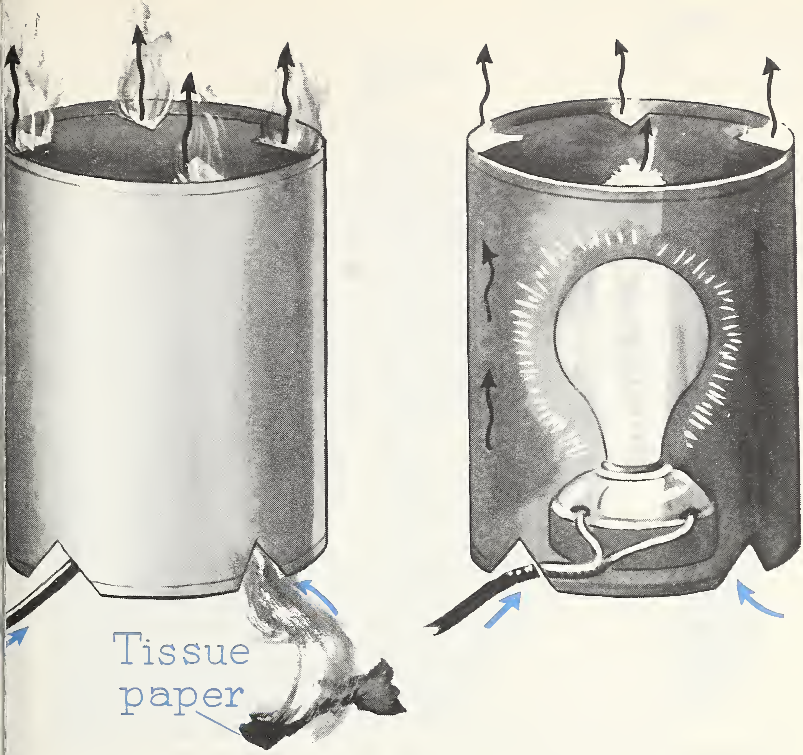
Many homes are kept warm by heaters that send hot air through the rooms. The picture below shows a small heater that can warm one or two rooms.

There is a stove in the heater. A fire burns in the stove. Cool air goes in the bottom of the heater. This air is heated by the stove. Then it comes out at the top of the heater.

Perhaps you can study a heater like this one. Sometimes the heaters are built in the walls or floors of rooms. Notice where the cold air goes in and the hot air comes out.







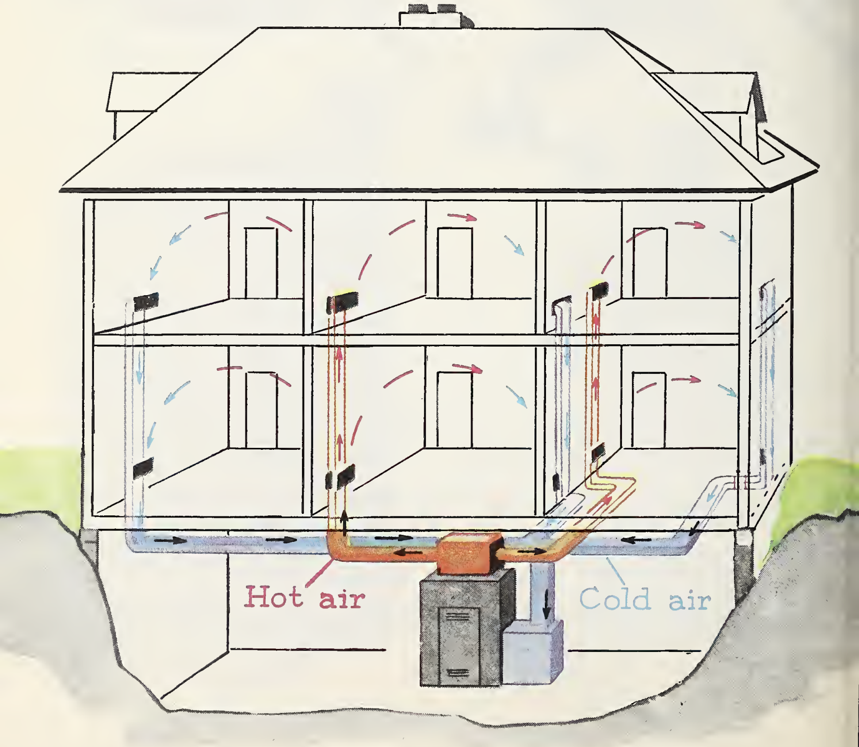
Make a model hot air heater from a can and an electric lamp. Punch holes in the can as shown in the picture. This can will be the outside of the heater. The electric lamp will be the stove.

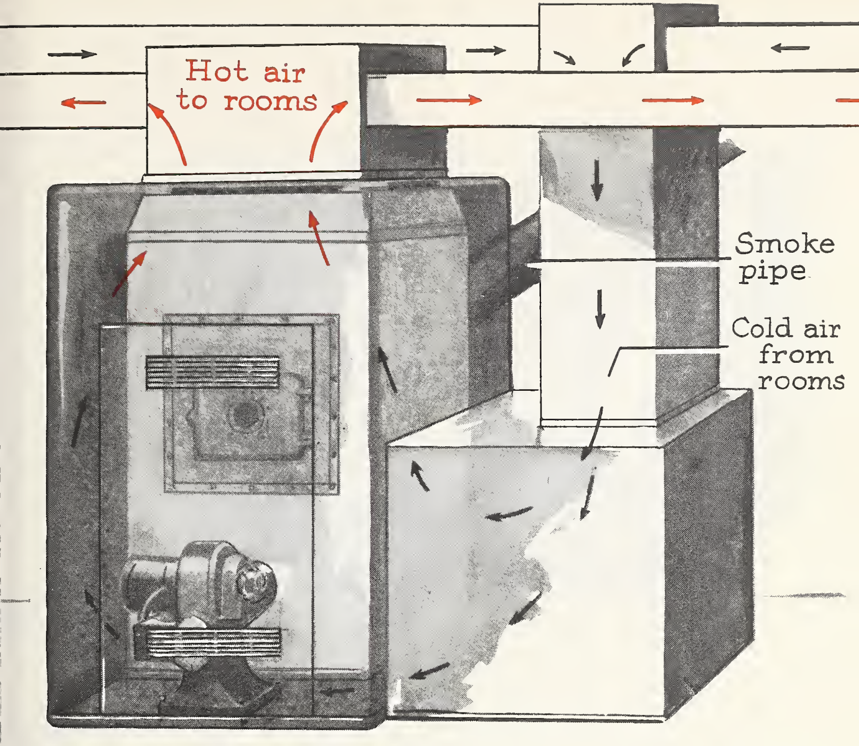
Hold your hand near the holes in the can. Does any hot air come out? Where?

Twist some tissue paper into a tight roll and set fire to it. Then blow it out. Smoke will come from the paper. Hold the paper near the holes in the can and watch the smoke. Where does air go into the heater?

In our country it is cold for several months of the year, and a large heater is needed. The heater is usually placed in the cellar. Pipes carry warm air up to the rooms. Other pipes bring cool air back to be heated.

In the picture, the warm air pipes have been coloured red and the cool air pipes have been coloured blue. Coloured lines show where the pipes are in the walls. Follow the path of the air from the heater to a room and back again.





Large hot-air heaters are much like the one you studied on the pages before this. There is a stove inside the heater. A pipe carries smoke to the chimney. Cool air goes in at the bottom of the heater and warm air comes out at the top.

Some heaters have a blower in the cool air pipe. The blower makes the air move faster.

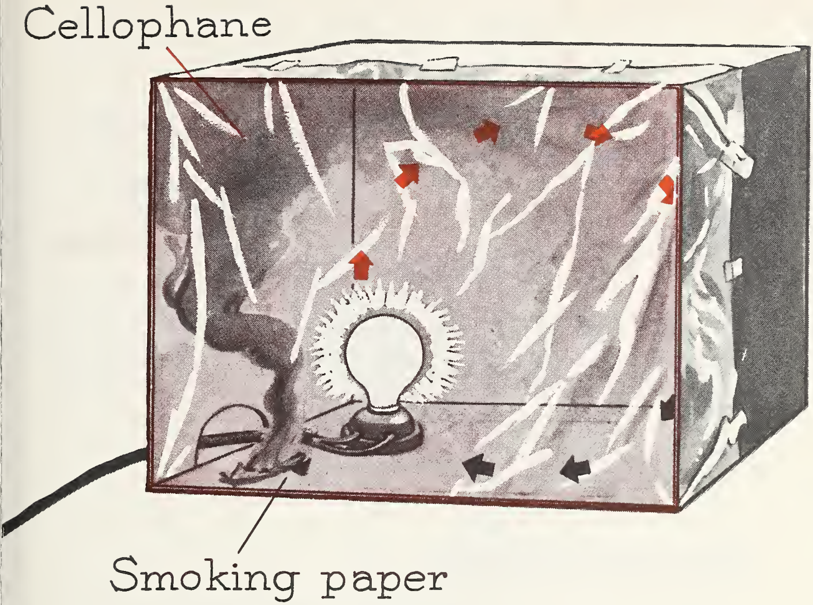
If you can study a heater like this one, look for the warm air pipes and the cool air pipes. You can often find them by touching them.

## Heated Air Rises

Hold your hand over something hot. Notice the warm air rising. Air usually rises when it has been heated.

Put tiny bits of milkweed fluff in the rising air. Notice how high they go. The fluff will show you how high the air goes before it cools and stops rising. What happens to the milkweed fluff then?

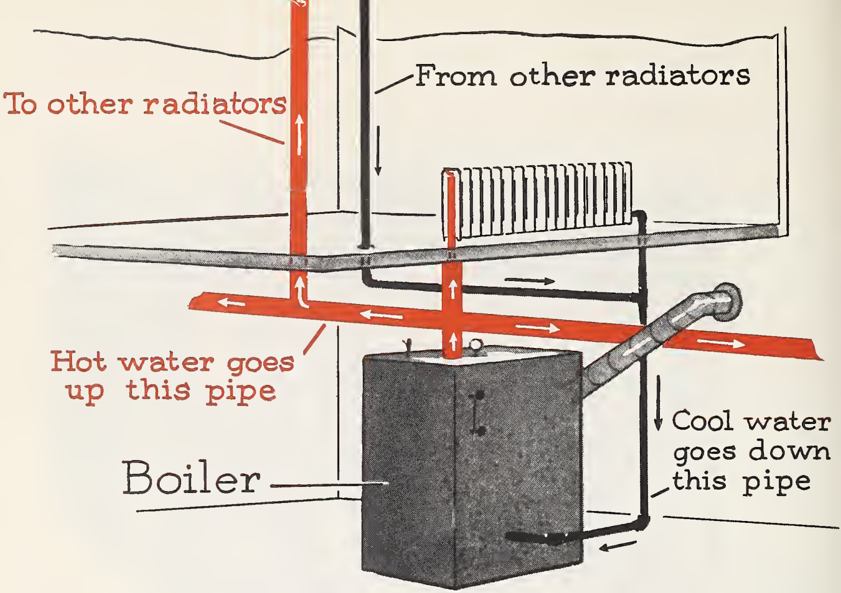
Where else have you noticed warm air rising?



Cover the front of a large box with a sheet of cellophane. Cut a hole in one side of the box as shown in the picture. Put a small electric lamp inside.

Then set fire to some rolled-up tissue paper. Blow out the flame and put the paper inside near the electric lamp. Watch the smoke from the paper.

Notice that the smoke rises in the heated air from the lamp. Notice that the smoke goes down again when the air at the top of the box cools. Perhaps you will see the smoke go up a second time as the air becomes heated once more.



## Hot-water Heating

Many homes are kept warm with radiators filled with hot water. Water is heated in a boiler. The boiler is usually in the cellar of the house.

Hot water rises from the top of the boiler. It goes up through pipes to radiators in the rooms of the house. There the hot water gives off its heat energy and becomes cool. Then it goes back down through other pipes to the boiler again.

Sometimes a pump is used to make the water move faster through the pipes.

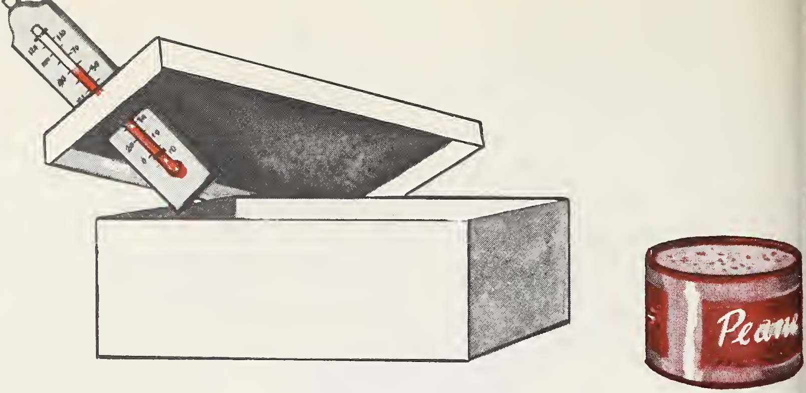
Is your home heated by hot water? If you can study a home heated by hot water, look for the boiler, the hot-water pipes, and the cold-water pipes.

This experiment will help you understand why hot water rises from a boiler to the radiators.

Fill an aquarium or glass jar with cold water. Then fill an ink bottle with hot, coloured water. Put the cap on the bottle.

Set the ink bottle on the bottom of the aquarium. Then take the cap from the ink bottle, being careful not to stir the water. Watch the hot water leave the bottle.

This experiment shows that hot water weighs less than cold water. Explain why the hot water rises.

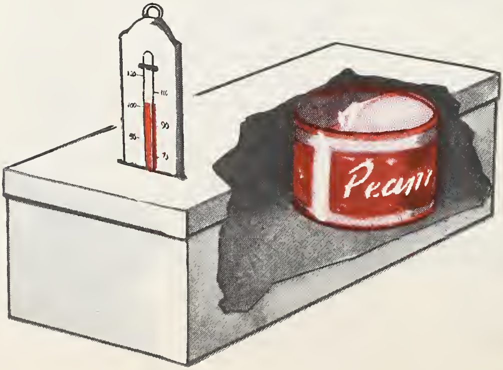


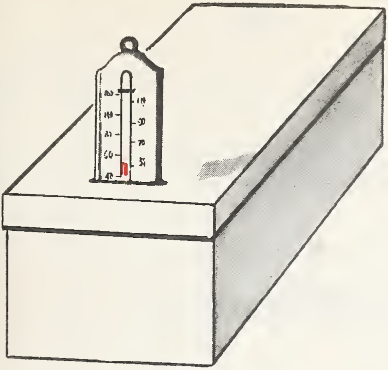
## How a Radiator Heats a Room

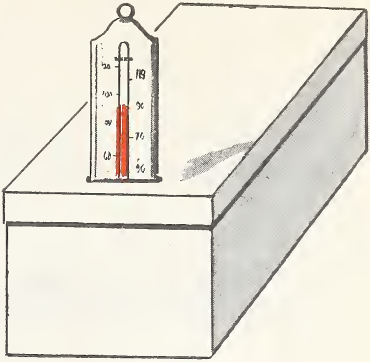
Cut a slit in the top of a shoe box. Push a thermometer through the slit and put the cover on the box. Read the temperature in the box.

Find a can with a lid. Fill the can with hot water. Set the can inside the box as far from the thermometer as you can. Close the lid and watch the thermometer.

The can of hot water acts like a radiator. The water heats the can. The can heats the air. In a short time all the air in the box is warmer.



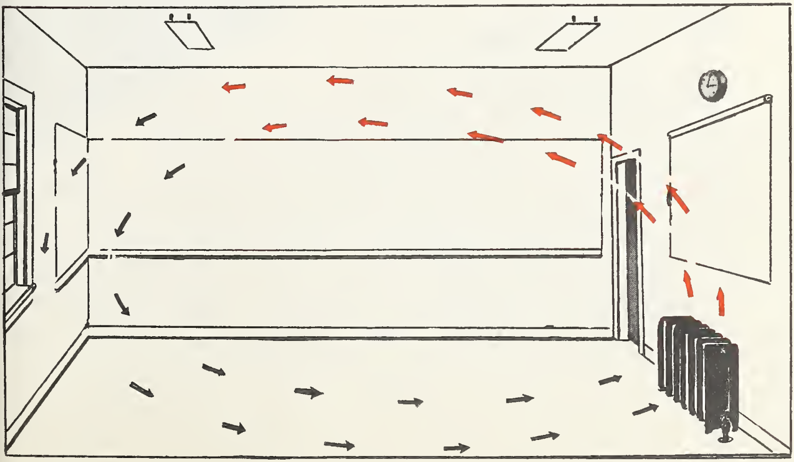


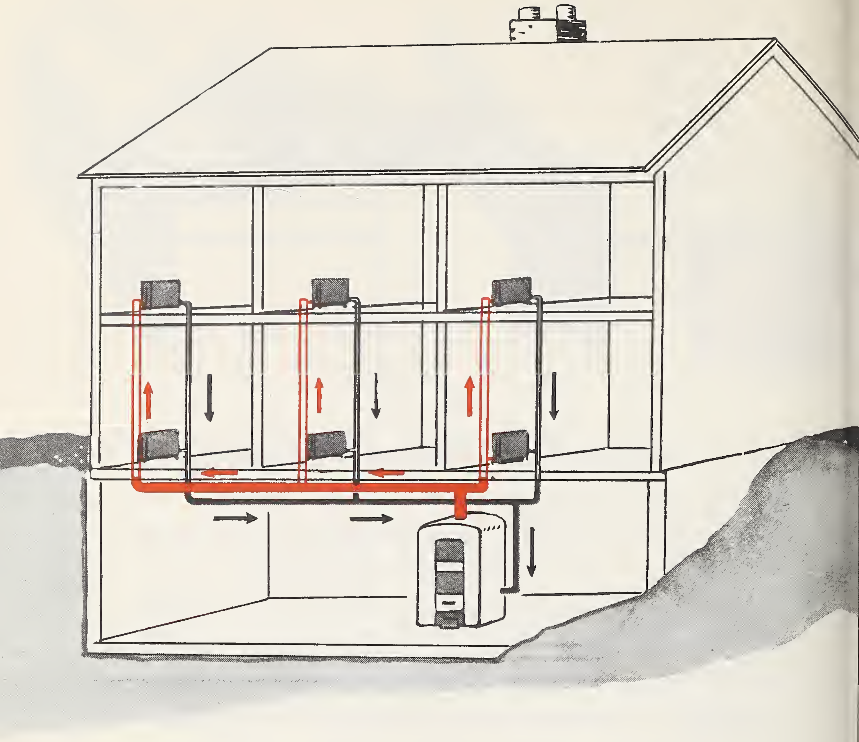


Find the temperature of the air at the top and at the bottom of the shoe box. Is there any difference? If so, can you tell why there is a difference? Try the experiment without the can of hot water in the box.

Is there any difference in the temperature of the air in your classroom? Take the temperatures at the floor, at the top of the room, and halfway up.

Explain the diagram at the bottom of this page.





## Steam Heating

Steam heating is much like hot-water heating. There is a boiler in which water is changed to steam. The steam goes up pipes to radiators in the rooms. There the steam gives off its heat energy and changes to water as it cools. Then it goes back down to the boiler.

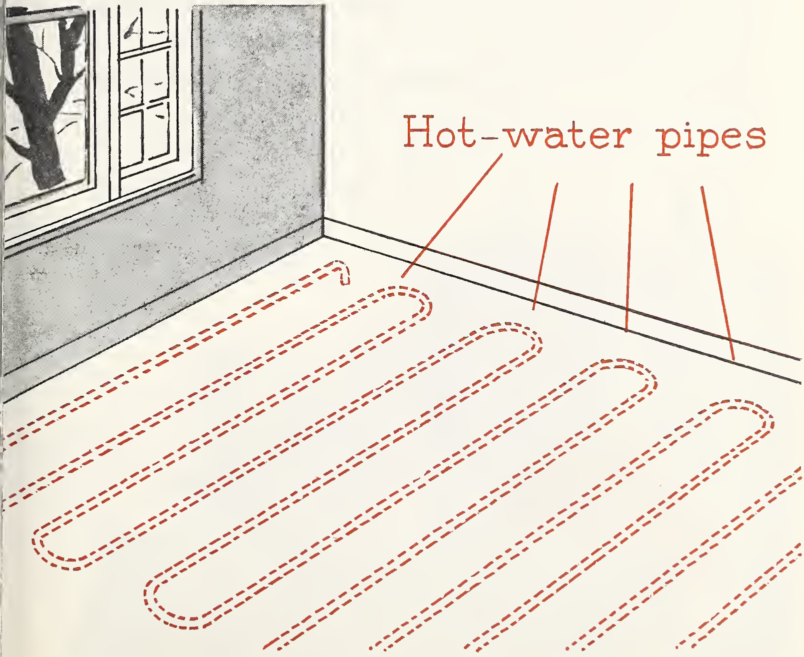
Steam heating is used in many large buildings such as hospitals and schools. How is your school heated? Make a study of the way your school is heated.

## Radiant Heating

There have been many experiments with ways to heat homes. Radiant heating is one of the ways that seems to be well liked.

Small hot-water pipes are bent back and forth through one of the walls, the floor, or the ceiling of the room. The whole wall, floor, or ceiling becomes warm and acts as a radiator.

The room is warmed more evenly and there are fewer draughts. The warmth is something like the warmth of sunlight and the warmth of a fire.

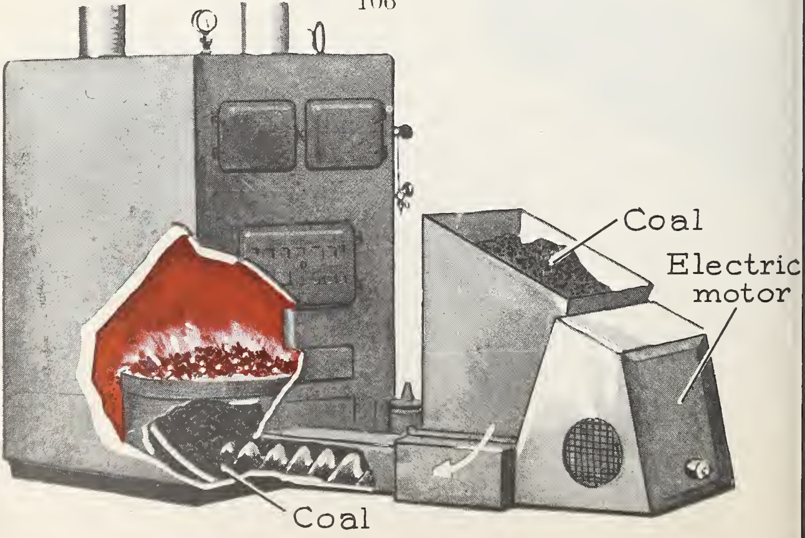


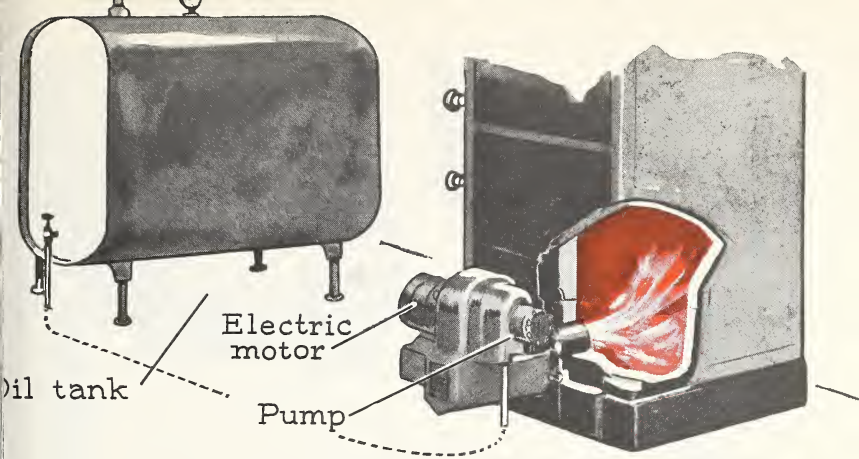
# Fuels for Heat Energy

Most homes are kept warm by burning fuels. A few homes use electricity for heat energy. A few other homes use the heat of the sun.

Coal is a common fuel. It is usually burned in a heater much as wood is burned. Air goes up through the fire from beneath. After the coal is burned, more coal is put in on top. Ashes fall through a grate into the bottom of the heater.

Machines have been invented to put coal in the firebox. They are called stokers. One kind of stoker is shown in the picture below.

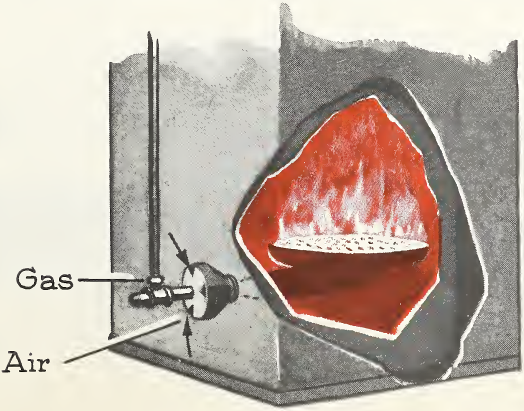


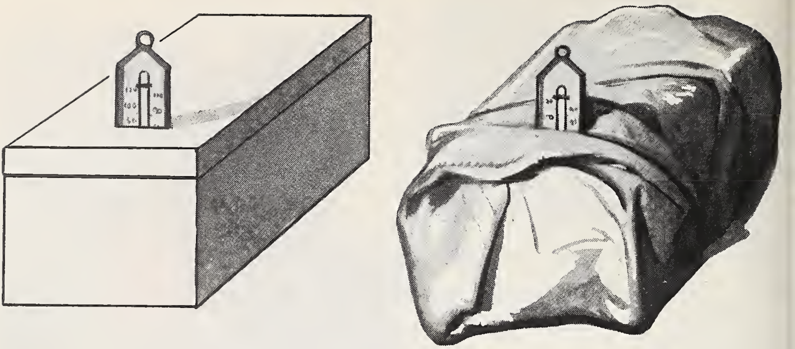


Oil is another common fuel. There are several ways of burning it. In one kind of heater, a pump forces the oil into the firebox as a fine spray. The tiny drops of oil heat and evaporate quickly and start to burn at once.

Gas is burned in many homes. Coal gas is made from coal. Natural gas comes from wells drilled deep into the ground. Gas is usually brought to homes through underground pipes, but sometimes it is brought in tanks. Then the gas is mixed with air and forced into the firebox of the heater.

What fuel heats your home? How is it burned?



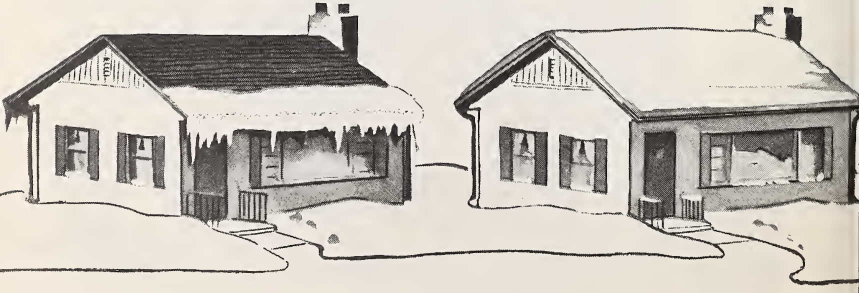


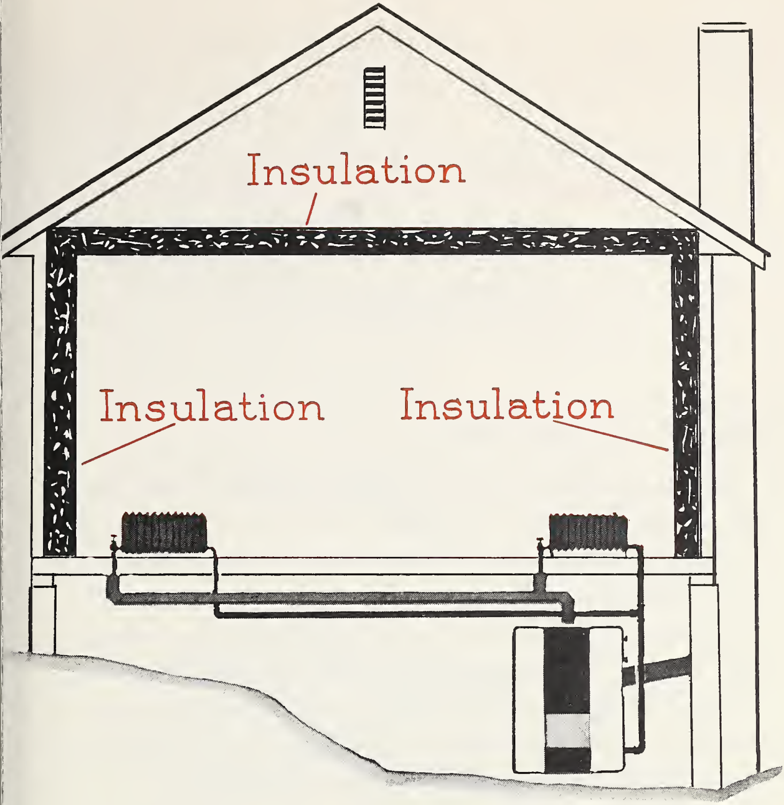
## Keeping Heat in a House

Put thermometers through the lids of two shoe boxes. Put a can of hot water in each box. Wrap one box with thick cloth. Watch the thermometers for half an hour. What happens?

The air in a box loses heat to the outside. The box stays warm longer if it is wrapped in something that does not let heat pass through rapidly.

In the picture below there are two houses side by side. One house is losing heat rapidly. We know this because the heat is melting the snow on the roof. Which house needs more fuel to keep it warm inside?





This picture shows how a blanket can be put around the rooms of a house to keep heat in. The blanket is made of something that does not let heat pass through rapidly. It is called **insulation.** A layer of insulation is put between the inner and outer walls of the house.

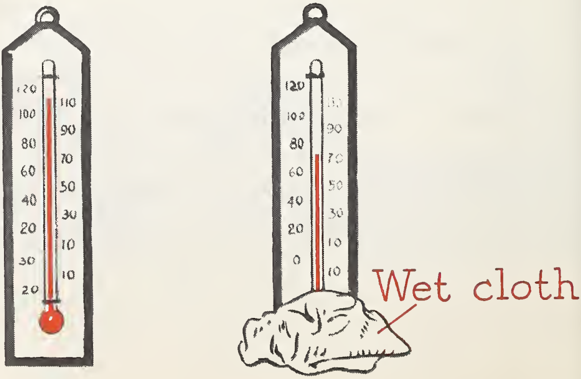
Visit a place where insulation is sold. Bring some of the insulation to school for study.

## Moisture in the Air

Mix some warm and cool water until it is at body temperature, about 98 degrees. Wet your bare arm with some of the water. Does your arm stay warm or does it begin to feel cool?

Heat energy from your arm helps the water evaporate. When your arm loses this energy it feels cool.

Wrap a bit of cloth around the bulb of a thermometer. Soak the cloth in water of room temperature. What happens as the water evaporates?

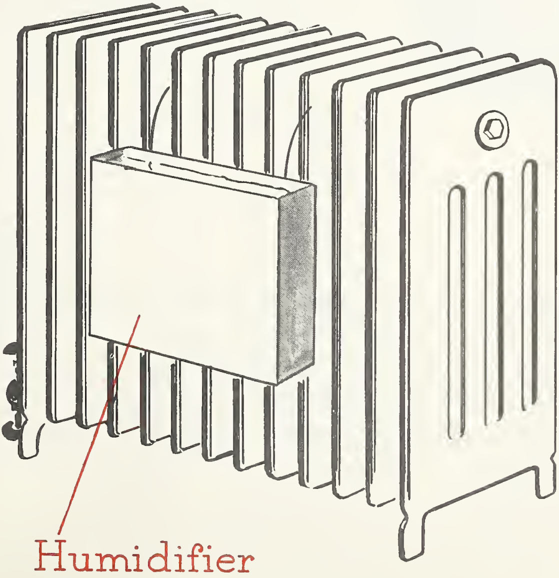


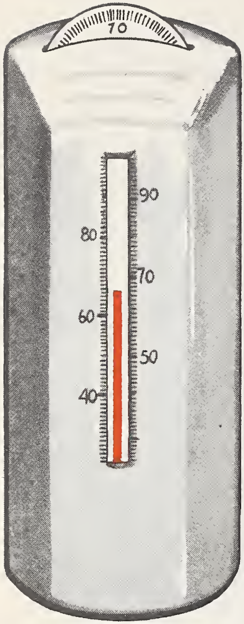
Water evaporates quickly in dry air. Moist things then become cooler. Notice how cold a wet cloth becomes in a dry room.

We sweat all the time. When the sweat evaporates it cools our bodies. We may feel cool in dry air even when the temperature is 70 degrees.

The air in most homes is very dry in winter. There should be some way of adding moisture to it. Then our sweat would not evaporate so rapidly and we would not lose so much heat energy.

There should be pans of water inside hot air heaters. There should be pans of water on radiators. Is there any way of adding moisture to the air in your home?





## A Thermostat

A thermostat is used to make a fire burn faster when the house becomes cool and to slow down the fire when the house becomes hot.

A thermostat can be set for different temperatures. The thermostat in the picture is set to keep a house at about 70 degrees. Look for a thermostat in your home.

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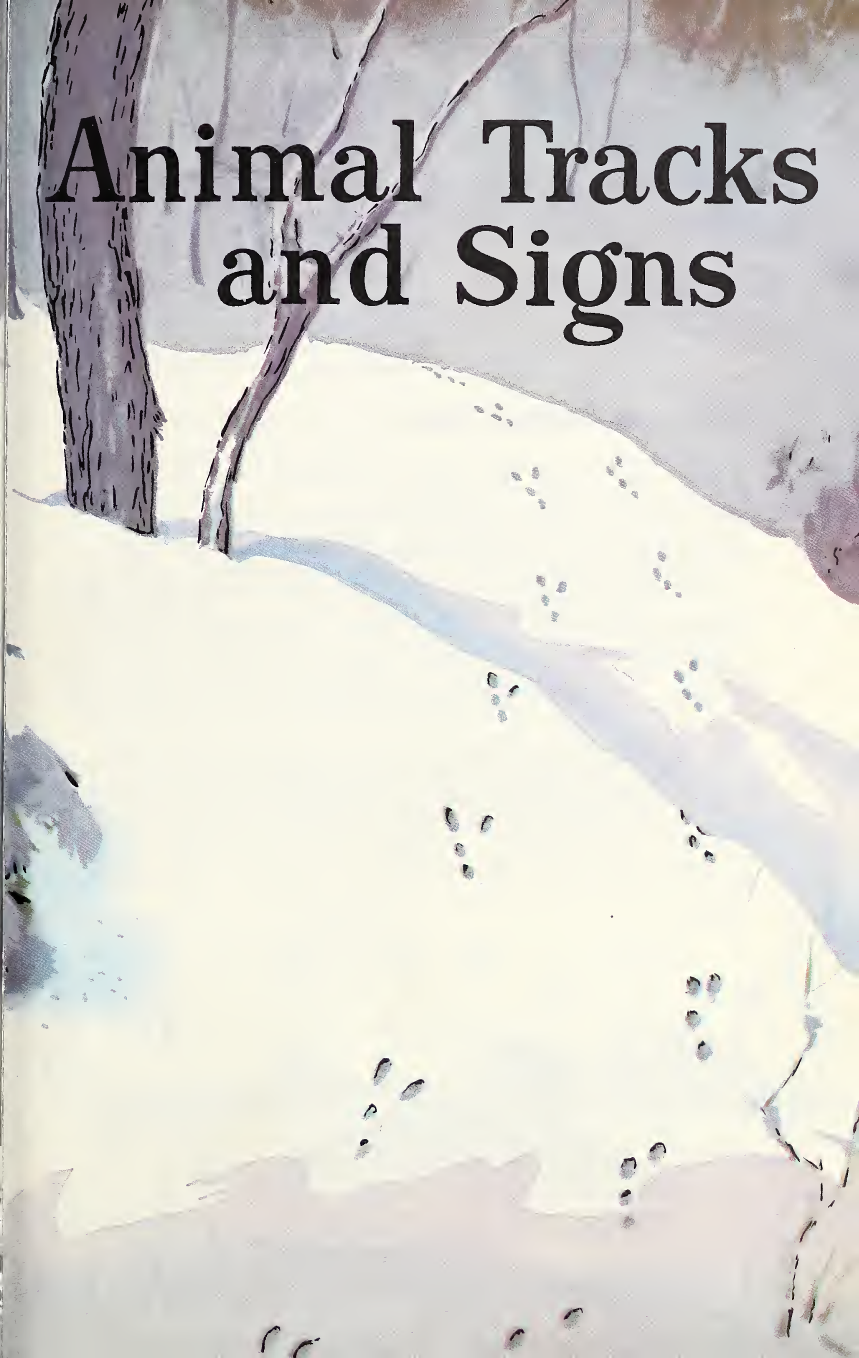
1. What are some common ways of heating homes?
2. How does a radiator heat a room?
3. What can be done to help keep heat in a house?
4. Why do we often feel cool in dry air?
5. Name some fuels used to keep homes warm.

# Animal Tracks and Signs

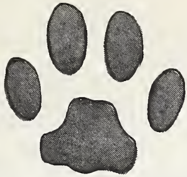


## Signs of Animal Life

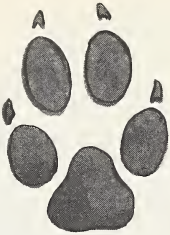
You may walk through the country for hours and never see the many animals that live there. Most wild animals are shy and they hide themselves very well.

But wherever you go you will find signs that the animals have left behind them. You may find their tracks and their runways. You may find burrows or houses. You may find tooth marks and other signs of feeding.

Indians and early settlers in the country had to know about these signs because they needed the animals for food and for clothing. Today, however, we study these signs because it is fun to know what the animals are doing.



Cat footprint



Dog footprint

## Cat and Dog Tracks

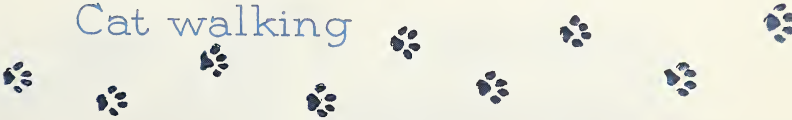
Cats and dogs are the most common animals around our homes. You will see their tracks almost everywhere.

Cat and dog tracks are somewhat alike. Look at the pictures on this page and find two ways that they are alike. Find two ways that they are different.

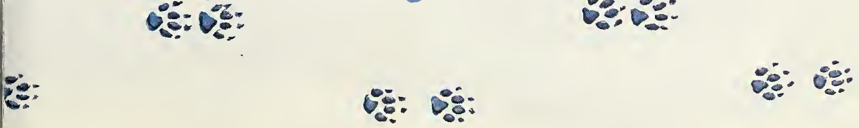
Notice that dog tracks show claw marks in front of the toes. Cats keep their claws pulled up when they are walking. Dogs leave their claws down.

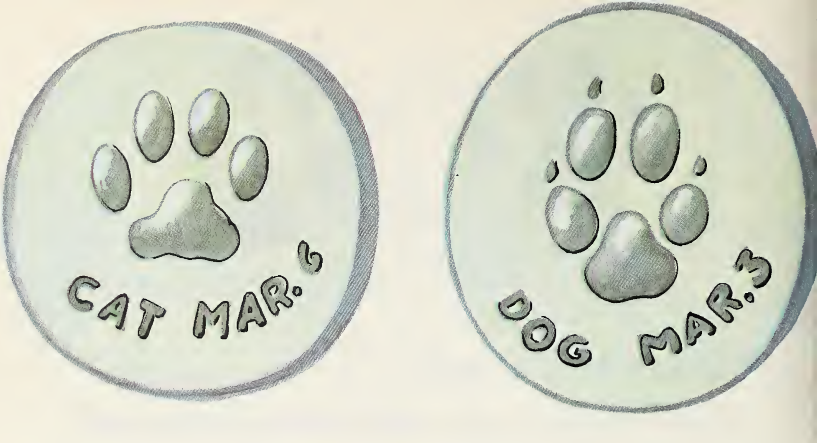
Notice also that cats usually put their hind feet in the tracks of their front feet. Dogs usually do not. Find some tracks of cats and dogs and study them.

Cat walking



Dog walking

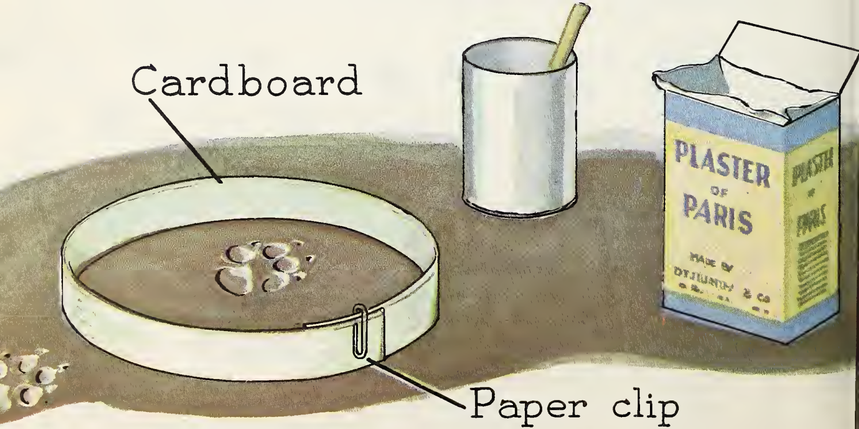


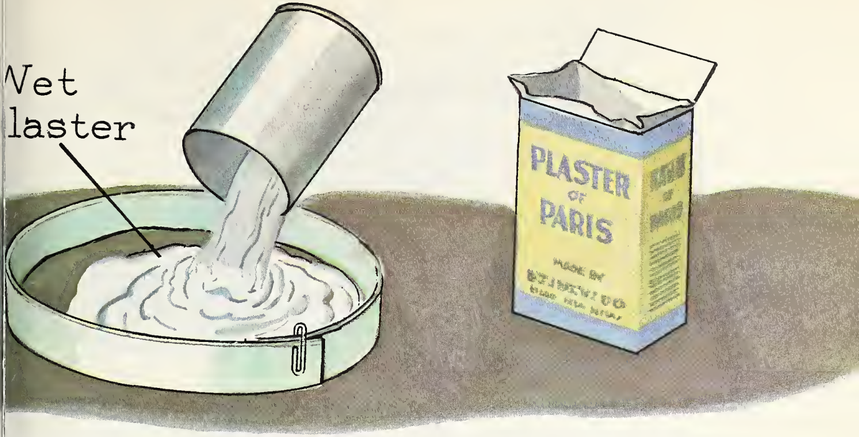


## Plaster Casts of Tracks

Plaster casts will help you in your study of tracks. The casts are made of plaster of Paris. You can buy plaster of Paris in stores that sell building supplies and in drug stores.

Find some fresh tracks in a muddy place. Cut a narrow strip of cardboard or metal long enough to go around the track. This will be used as a form to hold the plaster. Put the form around the track.

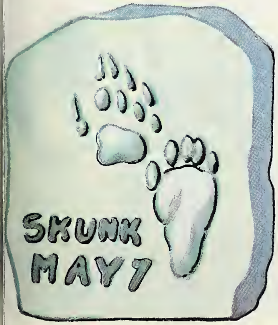


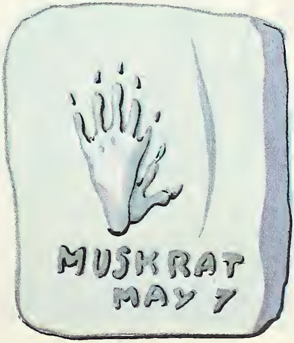


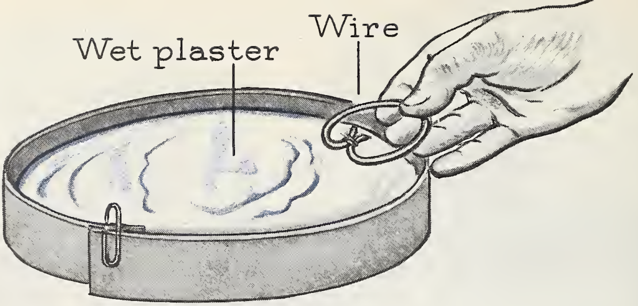
Plaster of Paris begins to harden a few minutes after it is mixed with water. Have everything ready before you start to mix it.

Use about a third of a can of water. Pour dry plaster slowly into the water and keep stirring it with a stick. Keep adding plaster until the mixture is about as thick as pancake batter.

Pour the plaster into the track. You may pick up the cast in about fifteen minutes. Then let it harden for a day or two before you try to clean the mud from it.

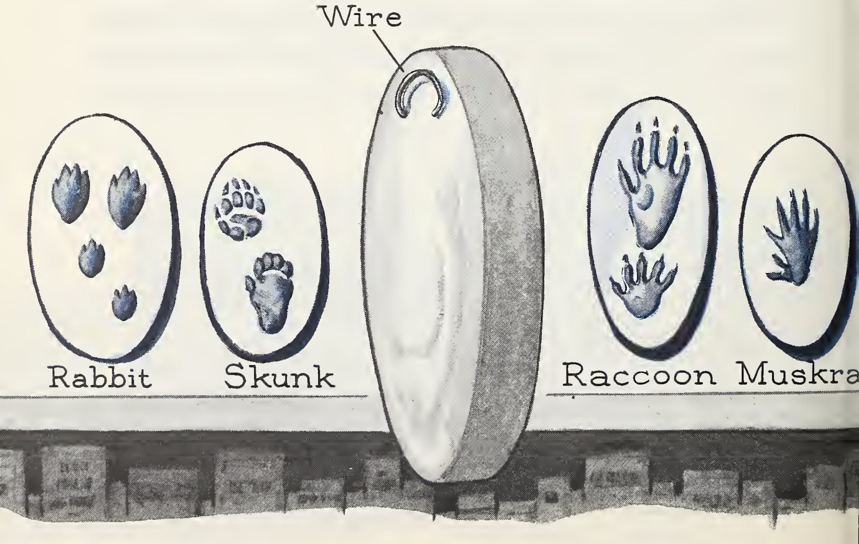


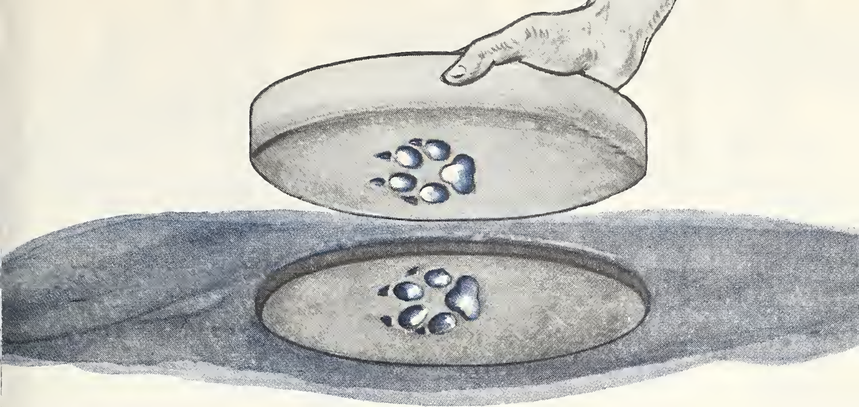




You can make casts that will hang on the wall. Press a loop of wire into the plaster before it is hard.

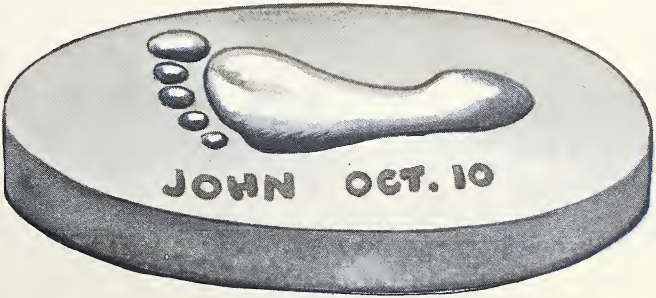
There are many kinds of tracks that you can have in your collection. Make casts of the tracks of different kinds of dogs, of wild animals including birds, and even of people. Casts of shoe prints will teach you how to know the footprints of men, women, and children.





After you have a cast of a track you can make other casts from it. Rub a little grease on the cast and press it lightly into fresh mud. When you pick up the cast, a track will be left in the mud. You can make a cast of this new track.

Then you can trade casts with people who have kinds that you do not have. You can build up a good collection this way.

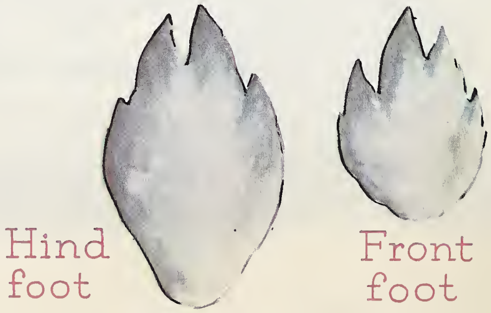


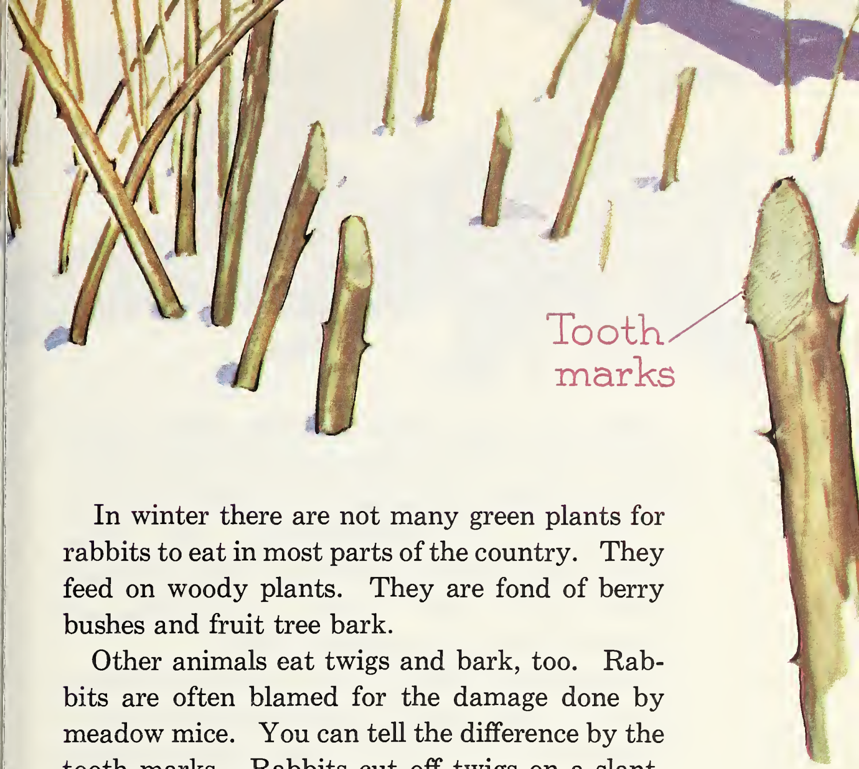
## Rabbit Signs

Rabbits live almost everywhere. They move around mostly at night, and you may never see them even when they live in your back yard. But if a light snow comes, you will see their tracks.

Many people think a rabbit has gone one way when it really went the other way. This is because rabbits put their hind legs ahead of their front legs as the rabbit in the picture is doing. The hind footprints are ahead of the front footprints.

Try to find the tracks of a rabbit. How far does the rabbit usually jump? You will be surprised when you find out how far a frightened rabbit can jump.

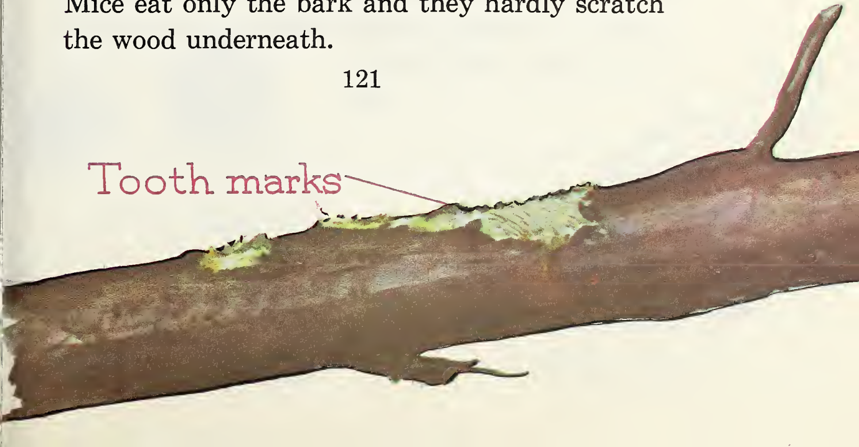




In winter there are not many green plants for rabbits to eat in most parts of the country. They feed on woody plants. They are fond of berry bushes and fruit tree bark.

Other animals eat twigs and bark, too. Rabbits are often blamed for the damage done by meadow mice. You can tell the difference by the tooth marks. Rabbits cut off twigs on a slant, and their tooth marks go across the twigs.

Rabbit teeth are also bigger than the teeth of mice and they dig into the wood under the bark. Mice eat only the bark and they hardly scratch the wood underneath.



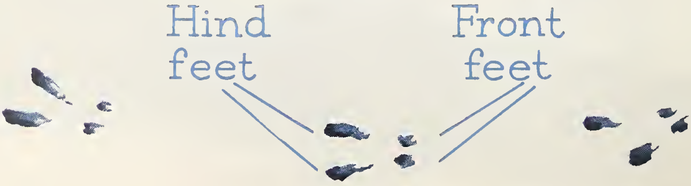
## Squirrel Signs

Squirrel tracks look something like rabbit tracks. They both put their hind feet down first. Large squirrels make tracks about the same size.

Look for some differences in the tracks. Notice that squirrels usually put their front feet down side by side. Rabbits usually put one front foot down ahead of the other.

Animals that live in trees usually put their front feet down side by side when they hop. Animals that live on the ground usually put one front foot ahead of the other when they hop or bound.

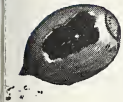
It is always well to follow animal tracks to see what the animal does before you try to name the animal. It is easy to make mistakes when looking at only a few tracks.

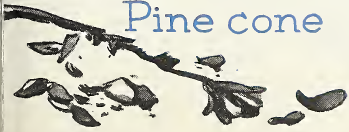


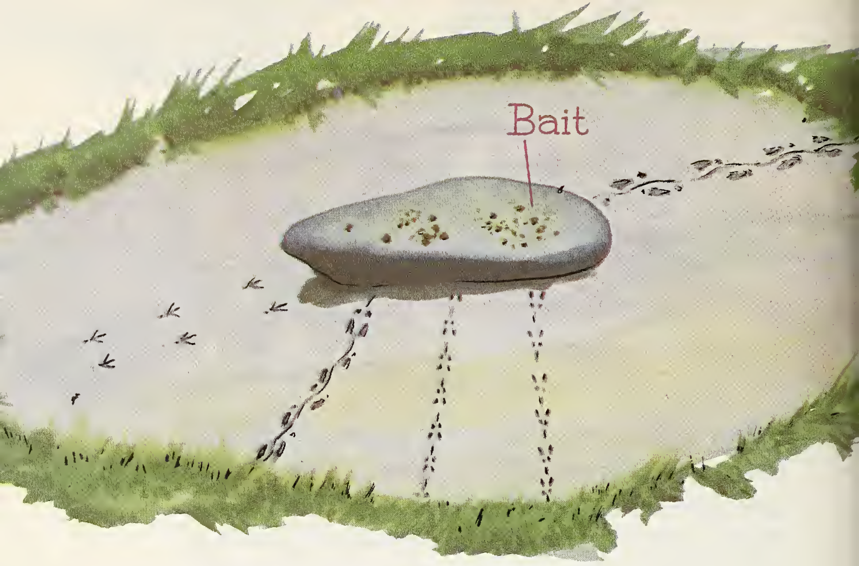
Red squirrels leave many signs where they have been. They make summer nests of fine bark and dry grass, sometimes in old birds' nests. They make winter nests in tunnels under logs and stumps. When the snow is deep, they dig tunnels in the snow.

They leave many feeding signs. They bite the scales from pine cones to get the seeds under the scales. They chew the husks from nuts, and then gnaw open the shells.

Often they do this work on some favourite stump or log. Then the scales of the pine cones and husks of the nuts pile up around the "workshops."







## Using Bait

Animal tracks show well in fine dust. If there is a flat place where no grass grows, you can use it to study animal tracks.

Smooth off a circle about six feet across and put a flat stone in the centre. Put a little food on the stone. Then scatter dust, fine sand, or sifted ashes in the circle. Smooth it by dragging a broom across it lightly.

Next morning look for tracks. Were there any visitors?

Try different kinds of food. Make drawings of the tracks in a notebook.

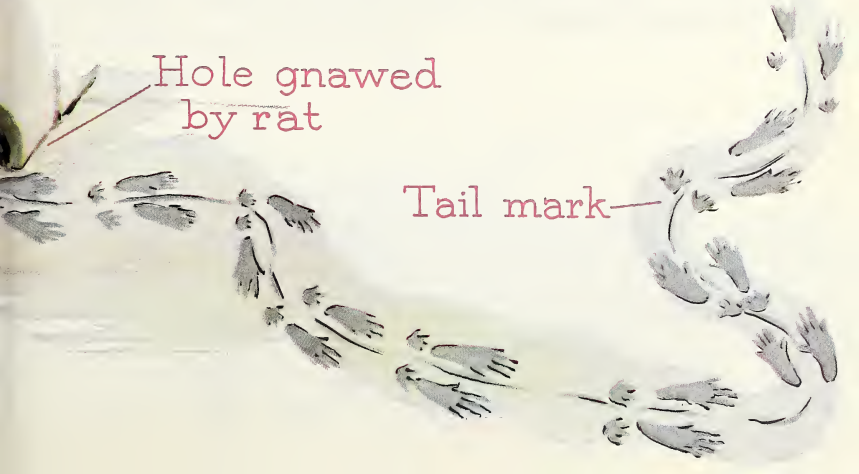
In winter you may put the bait in an open place and watch for tracks in the snow.

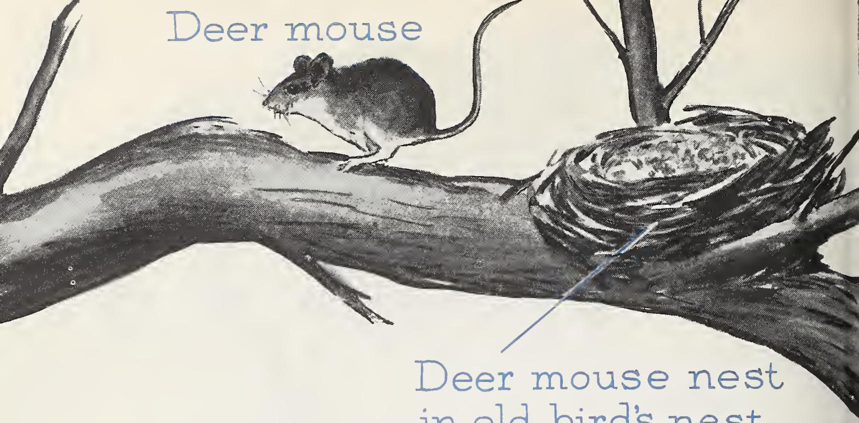
## Signs of Rats

Rats and mice may be among the visitors that come to your bait. Rats have long tails that drag and make a line between the footprints.

Good places to look for signs of rats are around barns and deserted buildings.

House rats are pests. They have strong teeth and they can gnaw their way into houses and barns. They damage food and grain. Sometimes they spread diseases.





## Signs of Mice

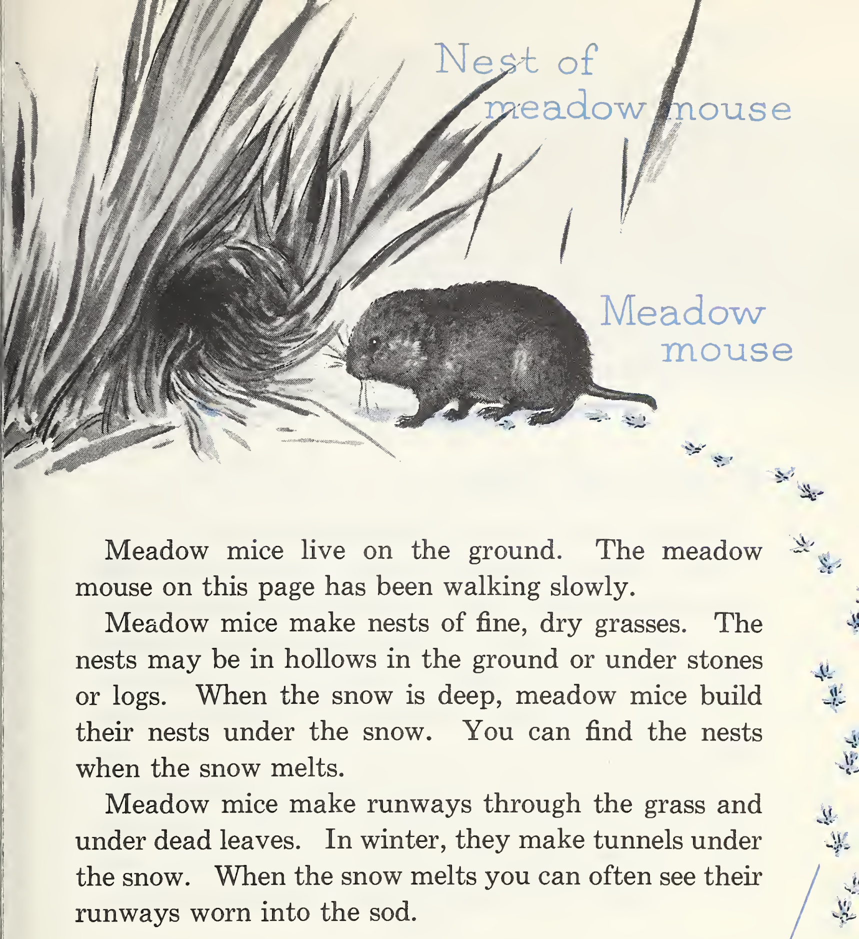
There are several kinds of mice. Around buildings you may find the tracks of house mice. In the woods you are most likely to find the tracks of deer mice. The tracks of these two kinds of mice look much the same.

When these mice hop, they put their front feet down side by side. Their tracks look something like tiny squirrel tracks.

Deer mice make nests of fine grasses and other soft things. You sometimes find their nests inside old birds' nests. You also may find them around old buildings and under bridges.

Tracks of
deer mouse

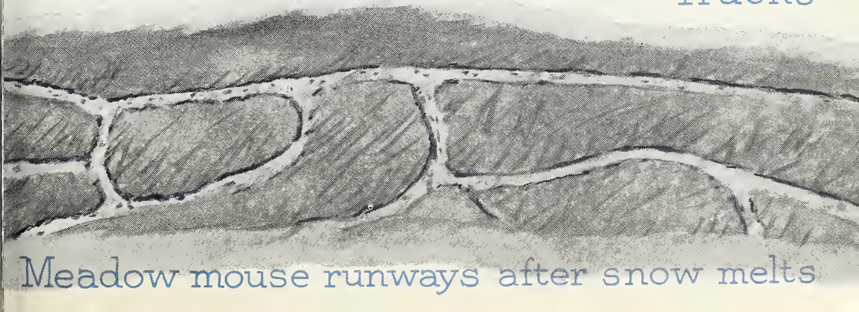
Deer mouse



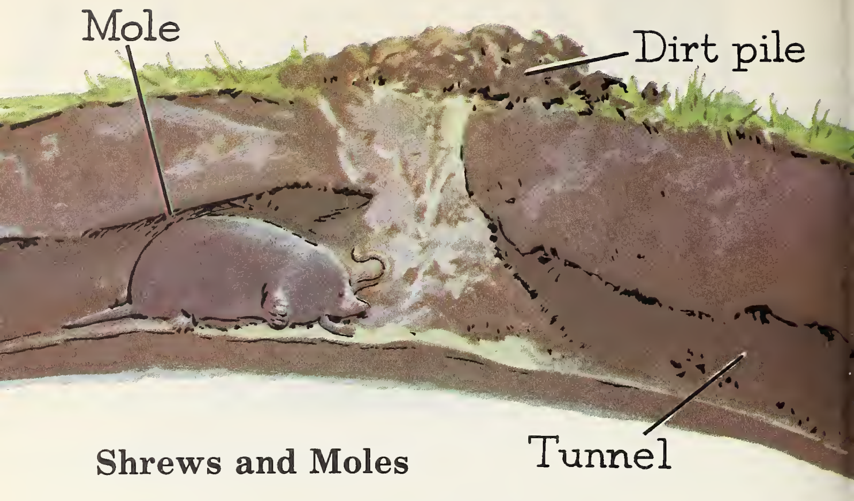
Meadow mice live on the ground. The meadow mouse on this page has been walking slowly.

Meadow mice make nests of fine, dry grasses. The nests may be in hollows in the ground or under stones or logs. When the snow is deep, meadow mice build their nests under the snow. You can find the nests when the snow melts.

Meadow mice make runways through the grass and under dead leaves. In winter, they make tunnels under the snow. When the snow melts you can often see their runways worn into the sod.



Meadow mouse runways after snow melts



## Shrews and Moles

Moles live underground nearly all the time.

They dig long tunnels in search of insects and other small animals that they eat. The moles push the soil from their deep tunnels up through holes to the top of the ground. If you lift up one of the piles of soil, you will see the opening to a tunnel. Try to find the openings to the tunnels.

Moles make tunnels near the top of the ground by pushing up the sod. Sometimes you will see ridges in a lawn. These were made by moles hunting for food. Why do people dislike these ridges in their lawns?

Ridges in lawn made by moles

Shrew

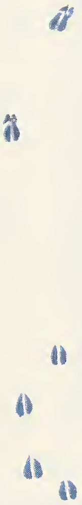
Shrews are relatives of the moles. Both shrews and moles look somewhat like mice, but there are many differences. Look at the pictures on these pages and find some of the differences. Can you find one difference between a shrew and a mole?

Shrews do not dig long tunnels as the moles do. They use the tunnels of moles and mice. They also run about on top of the ground more often than moles do.

In winter, you may see shrew tracks in light snow. Their tiny feet barely press into the snow. When they hunt for food, they put their pointed noses down like snowplows and leave a wide track in the snow.

Shrew tracks

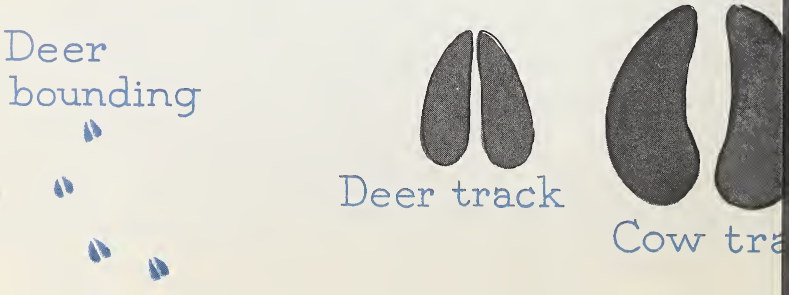
A shrew hunted for food in the snow



## Signs of Deer

Deer have hoofs much like those of cattle, sheep, goats, and pigs. All these animals make tracks that look somewhat alike. You can tell deer tracks from the others because deer hoofs have sharp points.

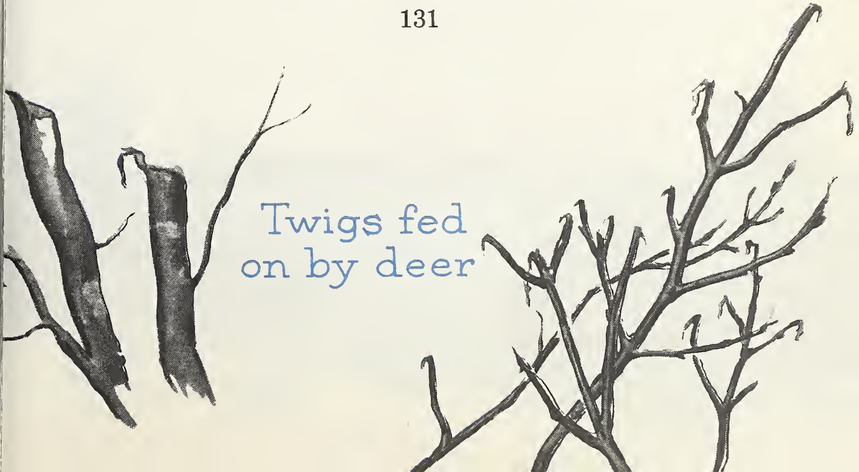
It is fun to track a deer if there is snow on the ground. You can see how the deer walks and how it runs. Perhaps you will see where the deer becomes frightened and begins to bound. You may see where it jumped a high fence. You may see where it lay down and rested.



Runway

Deer often use the same trails over and over until it is easy to follow them. These trails often lead to water. Tracks will tell you whether deer are using the trails.

You may see signs that deer have been feeding. Deer eat the twigs of bushes and small trees. They have no upper front teeth and they do not bite off the twigs as a rabbit does. They bite part way through the twigs with their lower teeth and then tear off the twigs the rest of the way. The stubs of the twigs are left with ragged edges.



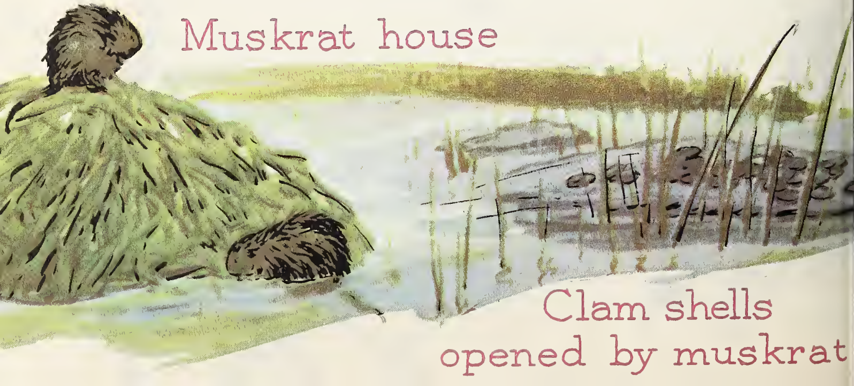
Twigs fed on by deer

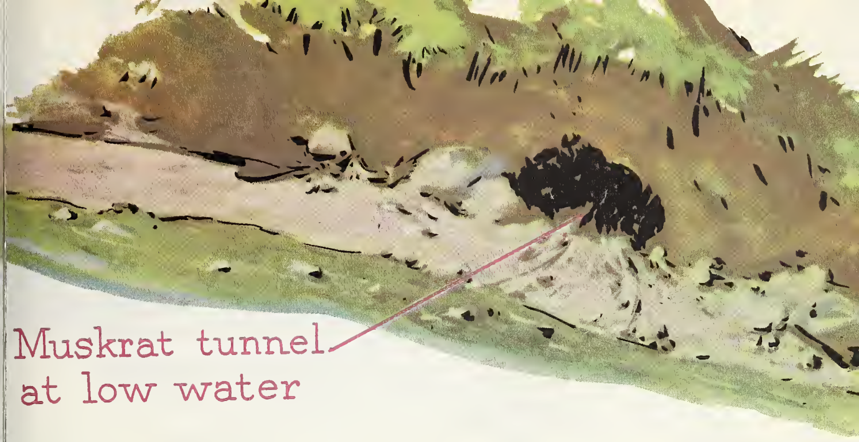
## Signs of Muskrats

Sometimes you see heaps of sticks, waterplants, and mud in small ponds and marshes. These are muskrat houses. Beaver houses are much larger and made only of sticks and mud.

Each muskrat house has a room above water level and an opening beneath water level. The muskrat can enter or leave its house without being seen.

Muskrats build new houses each fall. The houses usually fall apart during the summer.

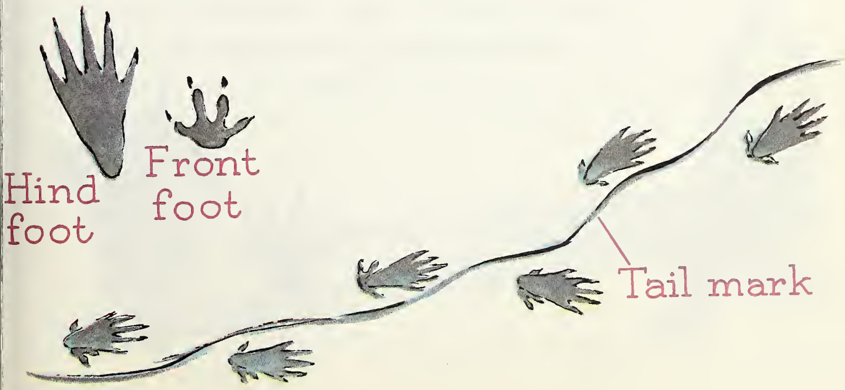

Muskrat house
Clam shells opened by muskrat

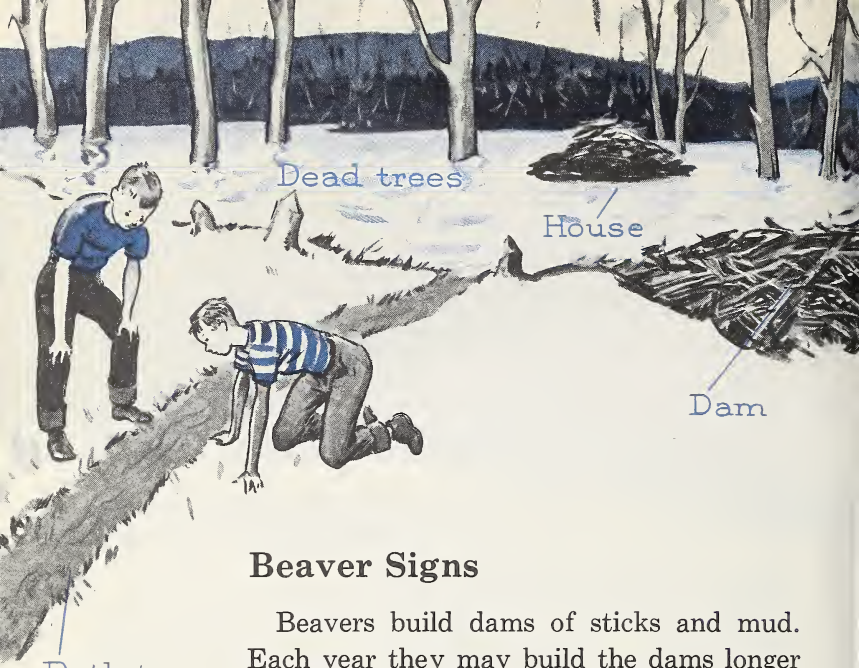

Muskrat tunnel at low water

Muskrats also make tunnels in the banks of streams. The opening of the tunnel is under water, and there is a room in the bank above the water.

The best time to find muskrat tunnels is when the water is low. Then the openings to the tunnels are uncovered. By looking carefully you can also see the openings when the water is high.

Perhaps you can find some muskrat tracks. The tracks look somewhat like the tracks of house rats, but the hind footprints are different. Look at the pictures in this book to see the differences.



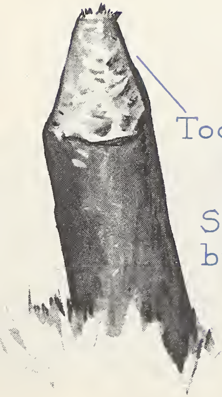


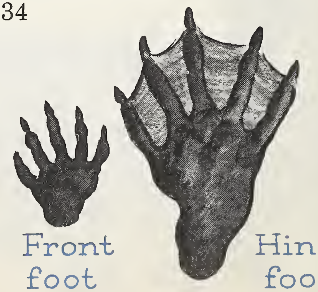
## Beaver Signs

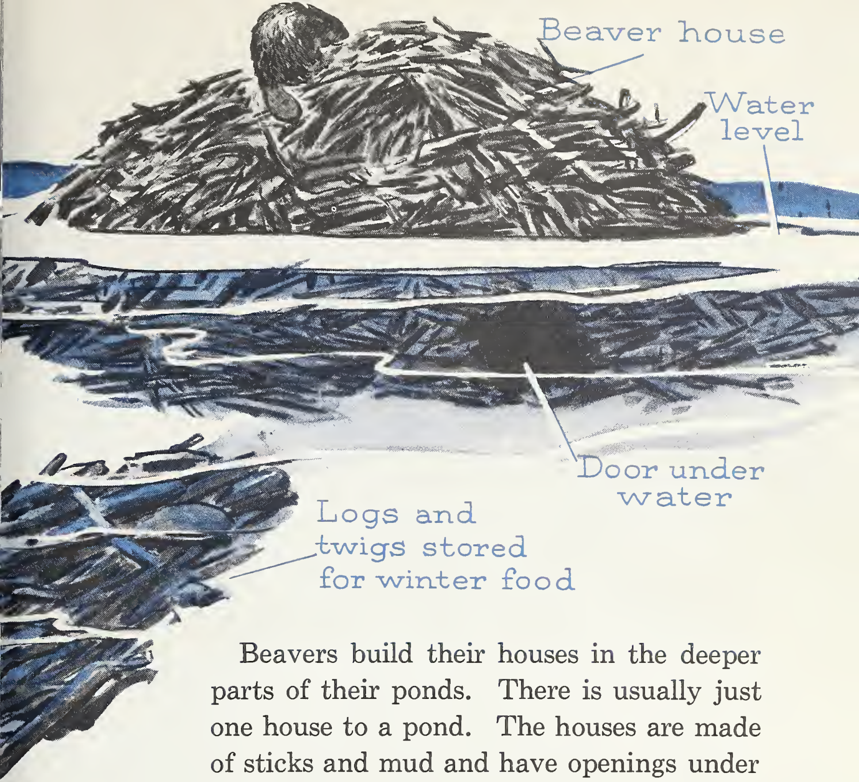
Beavers build dams of sticks and mud. Each year they may build the dams longer and higher. This sometimes makes ponds become as big as small lakes.

Beaver ponds are usually filled with dead trees. Most trees are killed when water covers the roots.

On the banks of the ponds you will find stumps of trees and bushes that the beavers have cut down. You can tell that beavers cut them because of the large tooth marks.

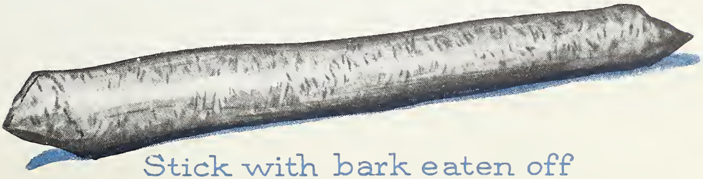




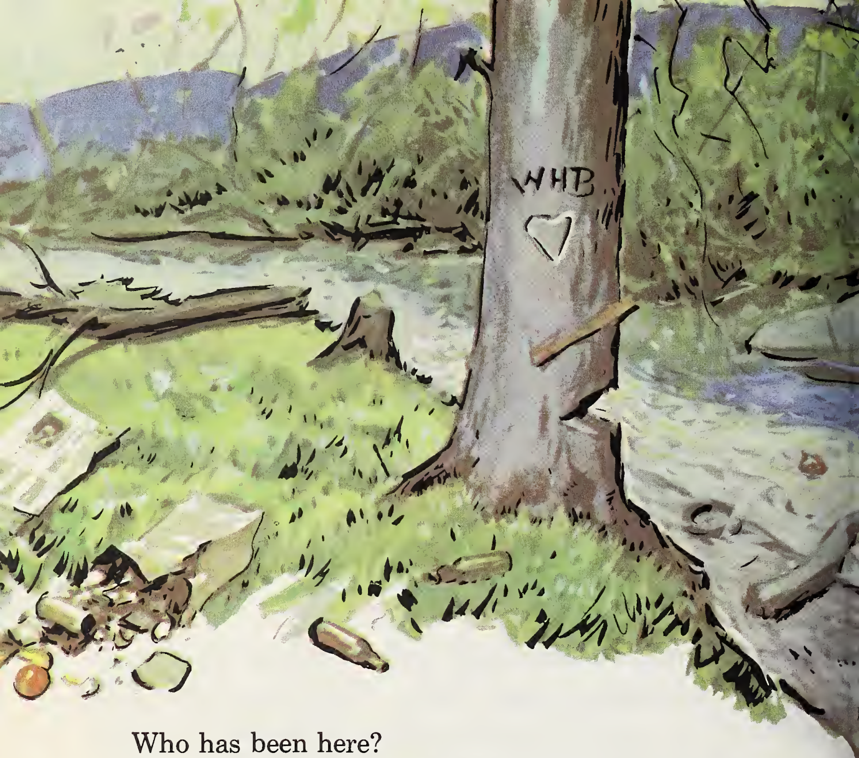


Beavers build their houses in the deeper parts of their ponds. There is usually just one house to a pond. The houses are made of sticks and mud and have openings under water.

Beavers eat bark during the colder months of the year. They cut trees into short logs and store them under water near their houses. In winter, they take these logs into their houses and eat the bark from them. Later they put the logs on the dams or on the houses. You will see many of these logs around beaver ponds.



Stick with bark eaten off

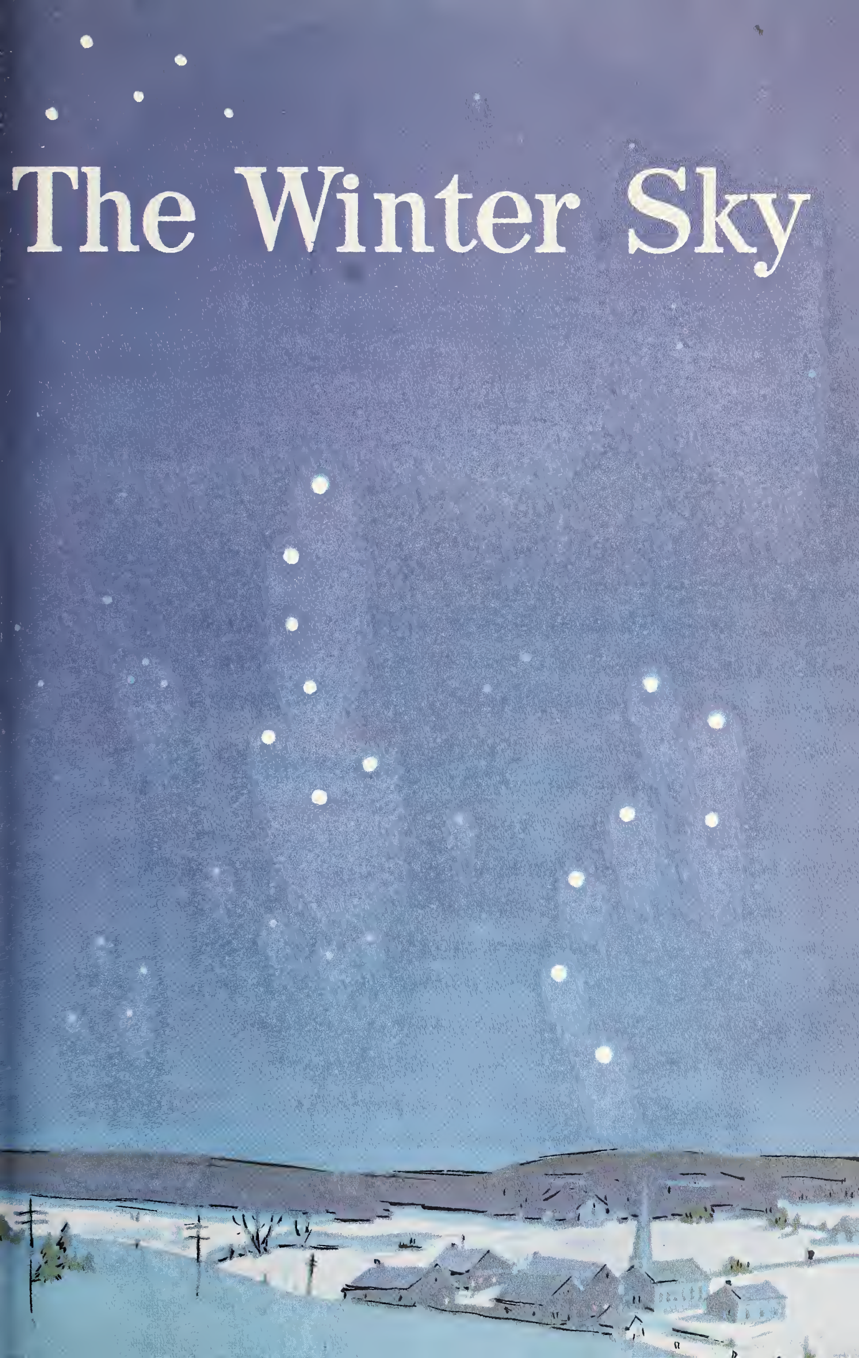


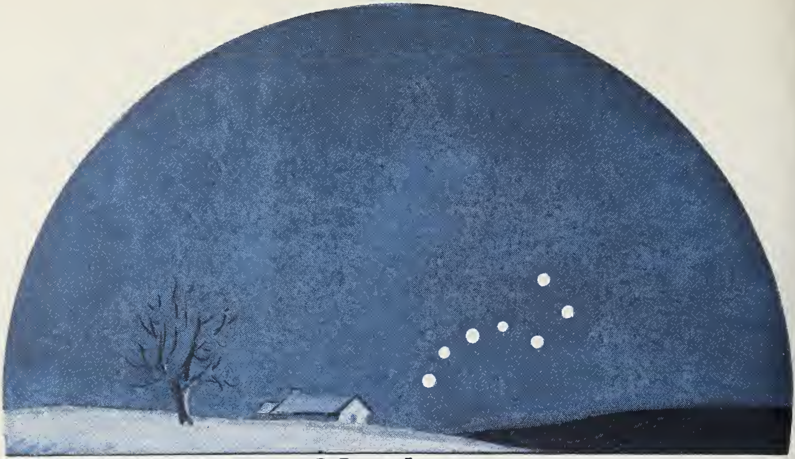
Who has been here?
What signs did he leave behind him?

---

1. What are some differences between cat and dog tracks?
2. What are some differences between rabbit and squirrel tracks?
3. What do rabbits eat when there are no green plants?
4. What are some differences between moles and mice?
5. Where do moles live?
6. How can you tell the footprints of deer?
7. What are some animals that make houses for the winter?

# The Winter Sky

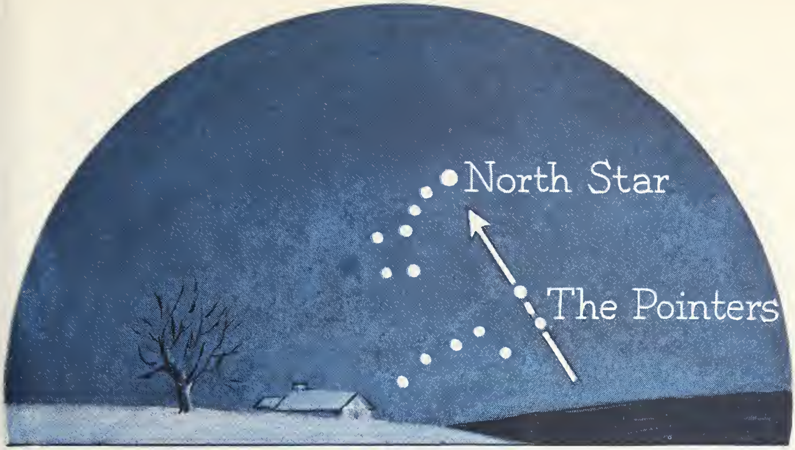




## Finding the Big Dipper

We shall begin our star study by learning to find the Big Dipper. This is a group of stars shaped something like a dipper with a bent handle. It has also been called the Great Bear.

The Big Dipper is in the northern part of the sky. If you face the place where the sun went down, the Big Dipper will be at your right. It is easy to find because the stars are all bright. On a winter evening, the handle hangs down.

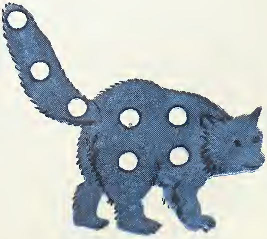


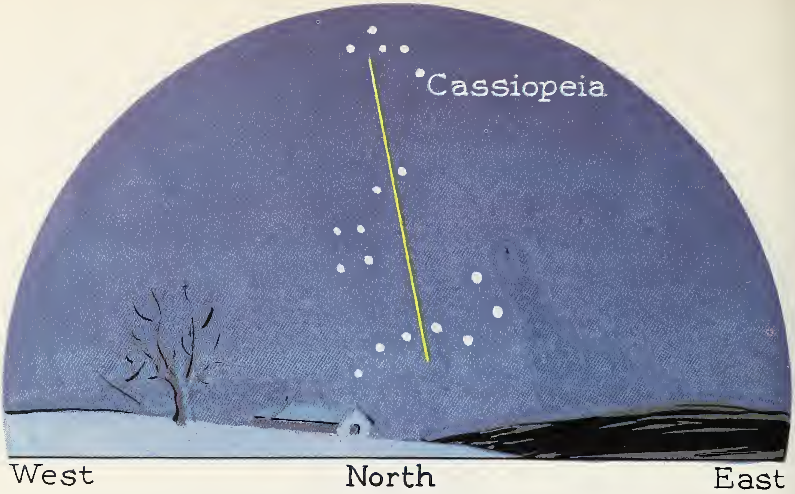
North

## Finding the North Star and the Little Dipper

The Big Dipper will help you find the North Star. Find the two stars at the end of the bowl of the Big Dipper. These stars are called the Pointers. A line drawn through these stars points to the North Star. The North Star is not a very bright star, but there are no bright stars around it.

The North Star is at the end of the handle of the Little Dipper. The other stars in the Little Dipper are dim, and you will not see them unless the sky is dark and very clear. The Little Dipper has also been called the Little Bear.





## Finding Cassiopeia

After you find the Big Dipper and the Little Dipper, you can easily find another star group called Cassiopeia.

Draw a line from the handle of the Big Dipper through the handle of the Little Dipper. The line will take you to a group of stars shaped something like the letter "M" or the letter "W." This is Cassiopeia.

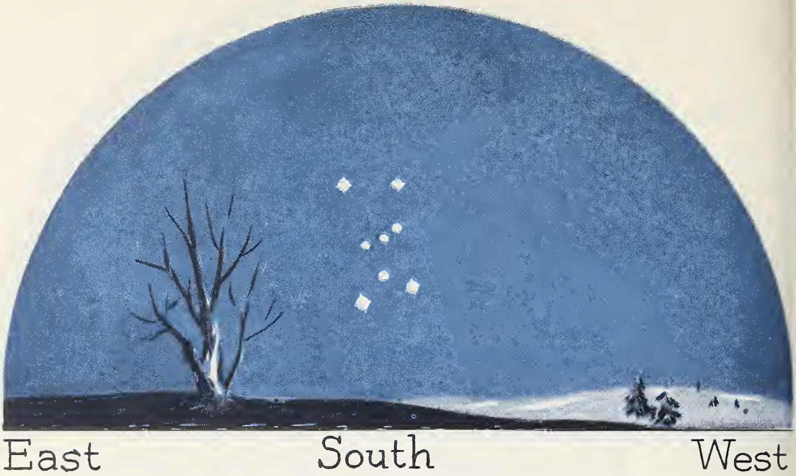
There are many stories about the star groups. Find some of these stories and read about the Big and Little Dippers and about Cassiopeia.

## Making a Star Finder

This star finder will help you find some of the star groups. Mark the centre of a tin can. Let this mark be the North Star and draw in the other star groups as shown on page 140.

Use a small nail to punch holes in the can where the stars are marked. You now have a map of a part of the sky around the North Star.

Take your star finder outdoors on a clear night. Face north. Shine a flashlight inside the can to light your map. Then you can look in the sky for the star groups like the ones on your star finder.

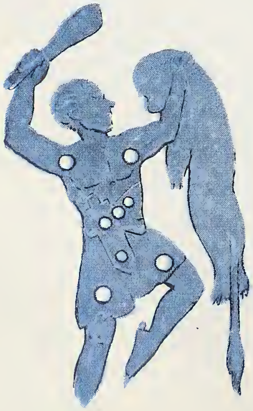


## Finding Orion

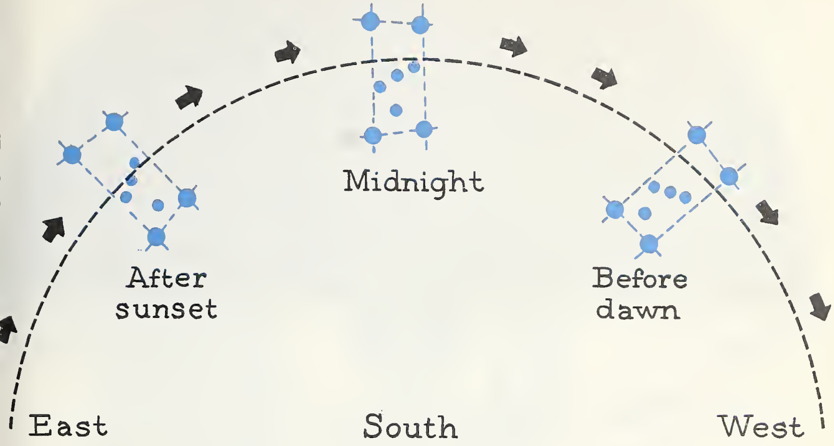
After you have found some of the star groups in the north, turn around and face south. There are many star groups in this part of the sky.

The easiest star group to find is Orion. Look for the three small stars in a row that are part of Orion's belt. Look for the dagger hanging from his belt. Then look for the four very bright stars on his body.

Read the story of Orion. Make a star finder to help you find Orion.



Orion

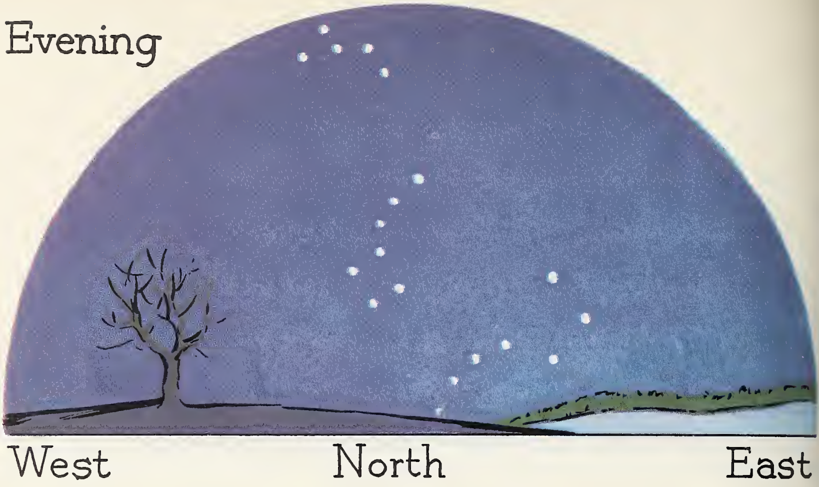


Look at Orion early in the evening. Look at it again before you go to bed. You will find that it moved. Which way did it move?

Pick out a star on the eastern sky line early in the evening. Look at it again an hour later. What happened to it?

Pick out another star near the western sky line. Look for it again an hour later. Can you find it?

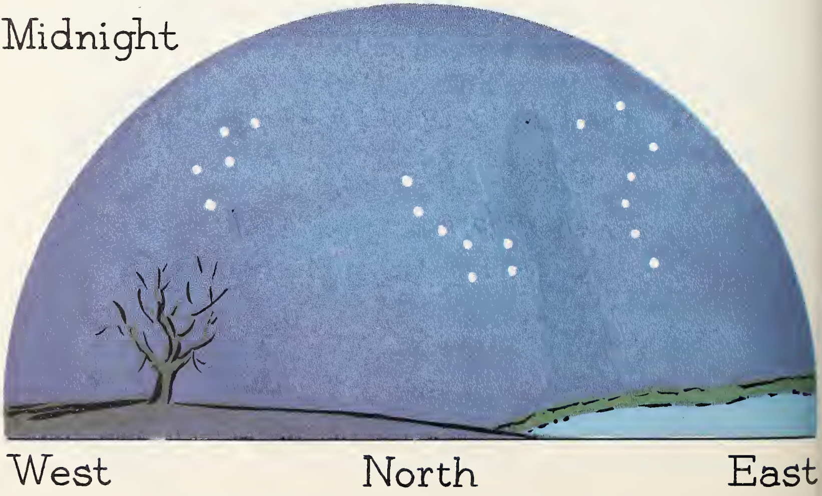
The stars in the southern sky rise in the east and move across the sky just as the sun and the moon do.



## The Stars Seem to Move

Look for the Dippers and Cassiopeia early in the evening. Look for them again later in the evening. Have they moved? Which way?

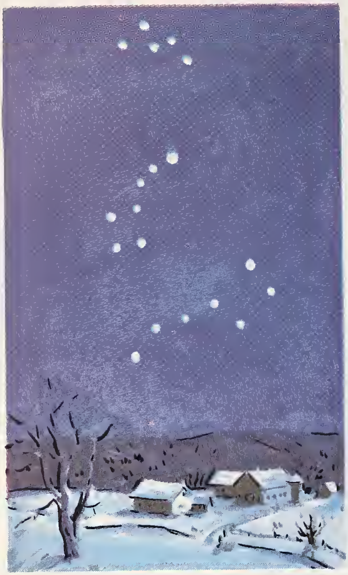
Here are pictures of the northern sky at two different times in the same night. Notice that the star groups have moved. Which star has not moved?

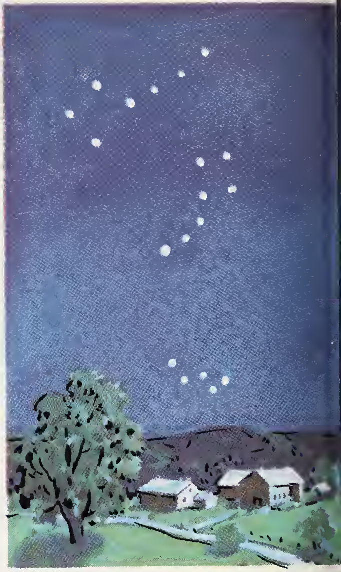


Throughout Canada, we do not see the Dippers and Cassiopeia rise or set. We see them move around the North Star without going below the skyline.

Draw the Dippers and Cassiopeia on the underside of an umbrella. The North Star should be at the very centre of the umbrella.

Hold the umbrella above the North Pole of a globe and turn the globe. This is the way we believe people on the earth see the stars. Now turn the umbrella so you can see how the stars seem to move. Notice that the North Star stands still and the other stars move around it.


January

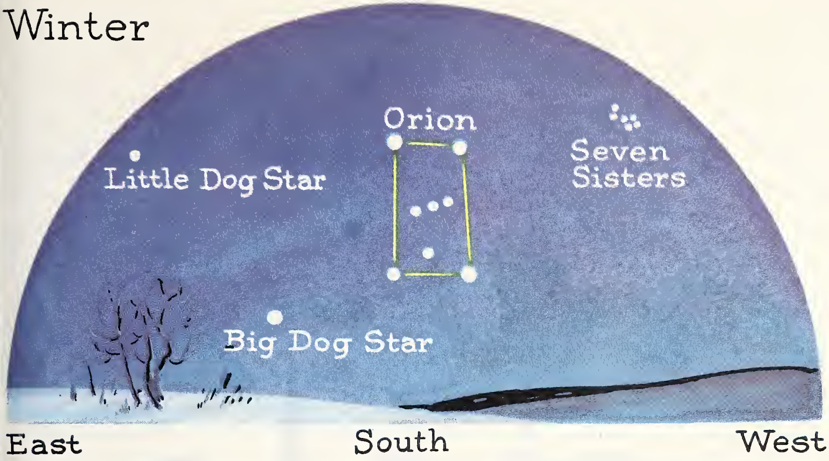

July

## Winter and Summer Star Groups

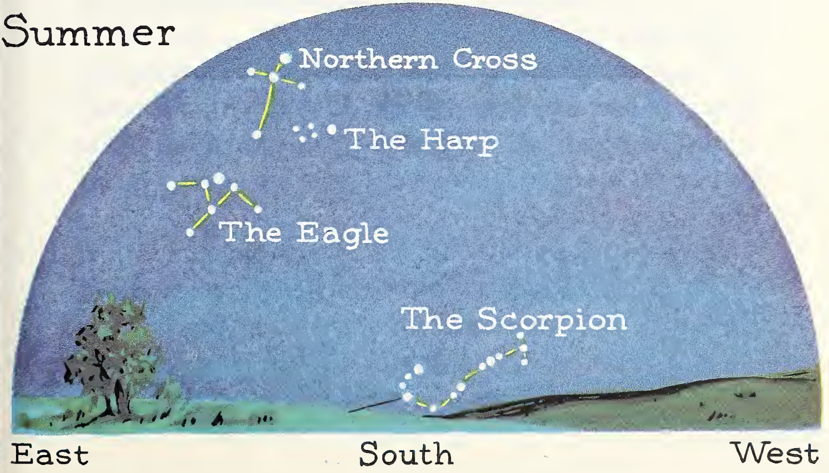
Next summer the skies will not look as they do now. Some of the star groups will be in new places. Other star groups cannot be seen and there will be some new star groups to study.

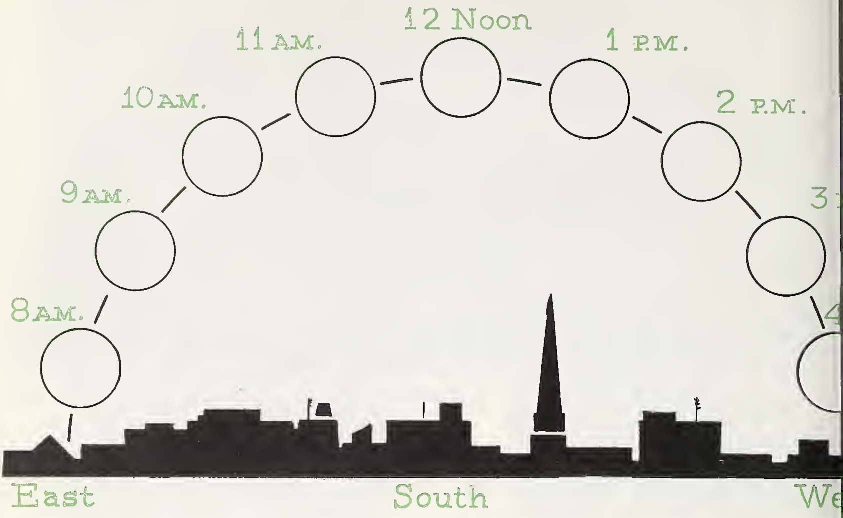
In the northern sky you can still find the Dippers and Cassiopeia but they will be in new places. Only the North Star will be in the same place.

In the pictures above, which star group is shown near the skyline in winter? Which star group is shown near the skyline in summer?



Here are pictures of the southern sky in winter and in summer. Notice that there will be several new star groups for you to study. But when winter comes again, all the star groups you have been learning about will be back again.



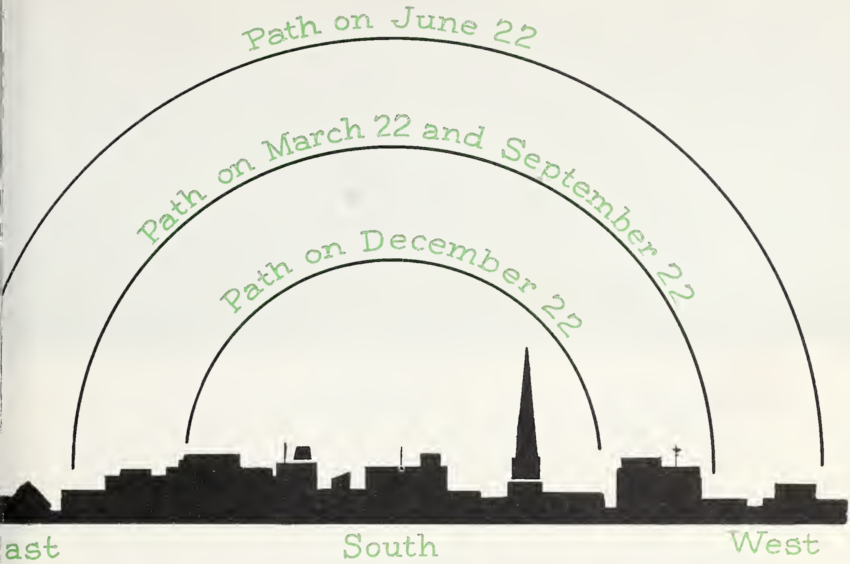


## Our Daytime Star

There is one star that we can see in the daytime. It is the sun. We believe that the sun is much like some of the stars we see at night. Because it is much closer, it seems much brighter.

Like the other stars, it rises in the east and sets in the west. We can use it as a clock. When the sun is south of us, we say that it is noon. When the earth has turned once and the sun is south of us again, we say that a day has passed.

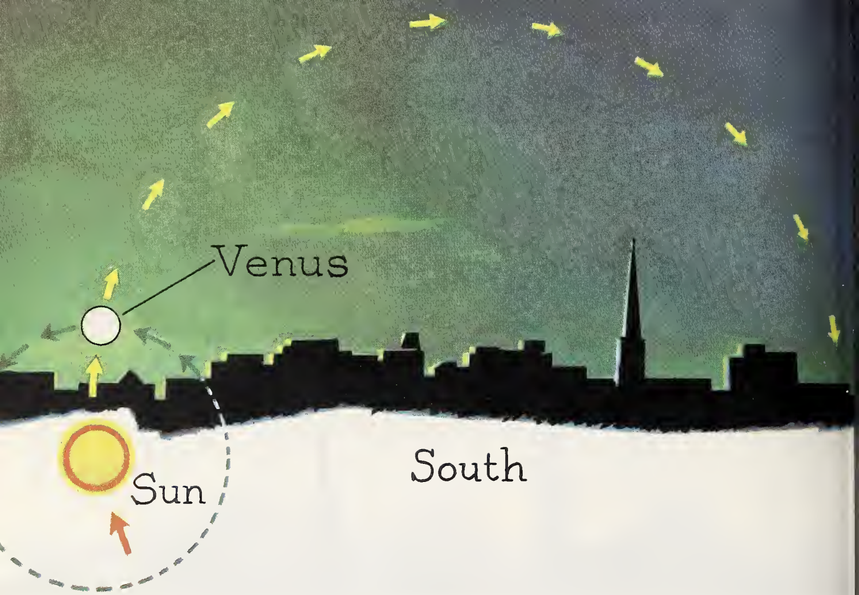
The sun also gives us energy. Heat from it keeps the earth warm. Light from it helps many plants to grow. The sun is the most important star in our lives.



The sun does not seem to follow the same path each day. Its path in winter is shorter and farther to the south than its summer path. We always see the sun in the southern part of the sky.

In which month is the sun's path longest? That is the time when we have the most hours of sunlight. In which month do we have the fewest hours of sunlight? When do you think the sun gives us the most energy?

People in other parts of the world see a different path of the sun. People in Australia look for the sun in the northern part of the sky. Their longest day is in December and their shortest day is in June. When does the sun give them the most energy?

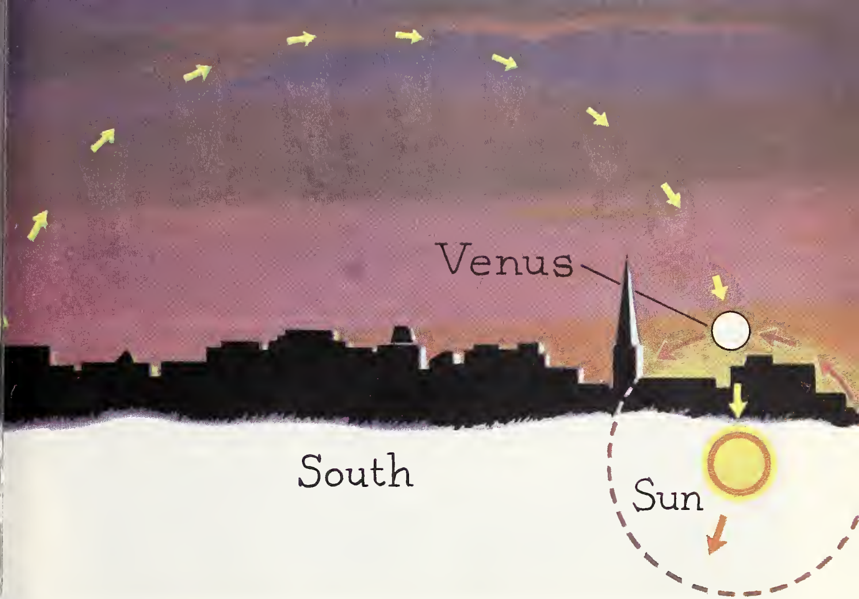


## Morning and Evening Stars

Some of the brightest stars are not really stars at all. They are worlds something like our own. They shine by reflected sunlight just as the moon shines. We call them **planets.** Our earth is a planet.

The brightest planet is called Venus. Sometimes you see it in the east before the sun rises. Sometimes you see it in the west after the sun sets. It is never far from the sun.

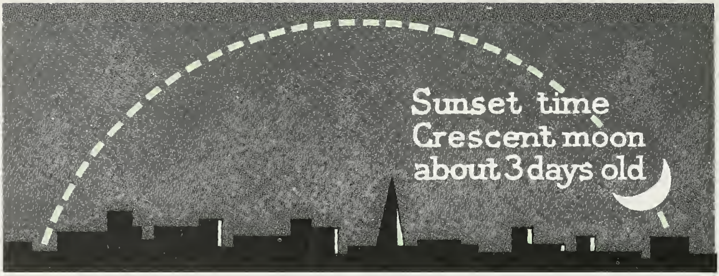
The picture above explains why we sometimes see it as a morning star. We believe that Venus goes around the sun. For several months it will come up ahead of the sun and we see it until the sun rises. The sun is too bright for us to see Venus during the day.

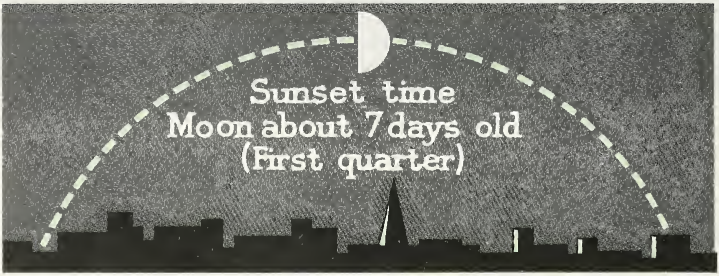


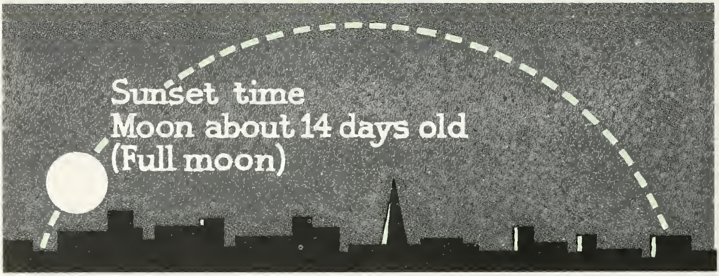
For several months Venus goes down after sunset, as is shown in the picture above. We see it from the time the sun sets until Venus sets. Venus is then seen in the west and is called the evening star.

An almanac will tell you when you can see Venus as an evening star and when as a morning star. Some newspapers also will tell you. The dates when you can see Venus change each year, so you must always look them up.

Three other planets that you can see are Jupiter, Saturn, and Mars. Sometimes they are morning and sometimes evening stars; sometimes you can see them late at night. An almanac tells you when they can be seen.



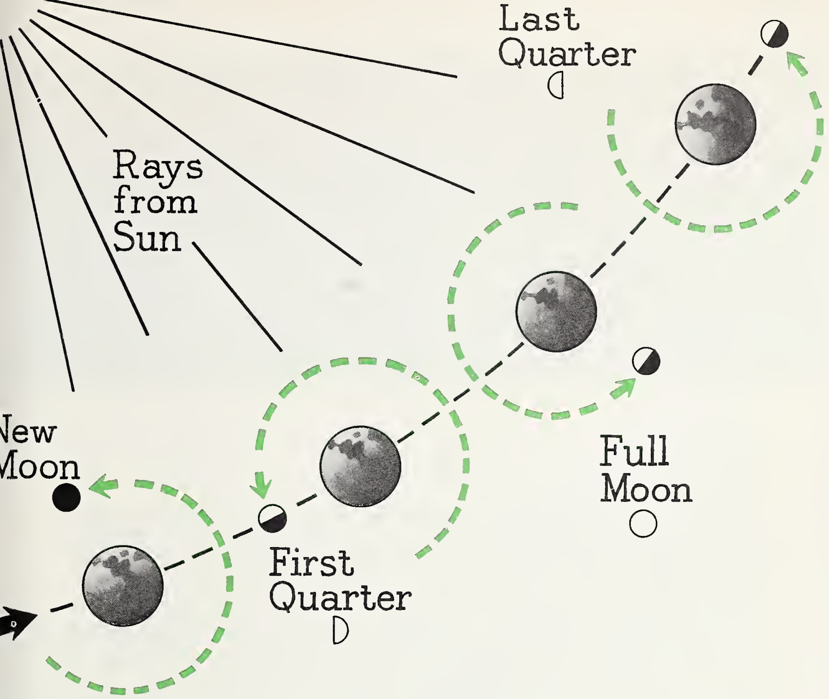




## The Moon

About once a month there is a full moon. At other times you will see some other shape of moon. For a few days each month you will see no moon at all.

Begin keeping a record of the moon. Draw the skyline as you see it. Draw the moon each time you see it.



We see the moon because it reflects sunlight to our eyes. We can see only the lighted part. The amount we see changes every day.

The moon goes around the earth about once a month. For half the time, it is farther from the sun than we are. Then the lighted part is toward us. For one or two nights we see all the lighted part. That is the full moon.

For the other half of the time, the moon is closer to the sun than the earth is. Then we see only a small part of the lighted side. For one or two days, we cannot see any of the lighted side. This time is called the "dark of the moon" or the "new moon."

## Meteors

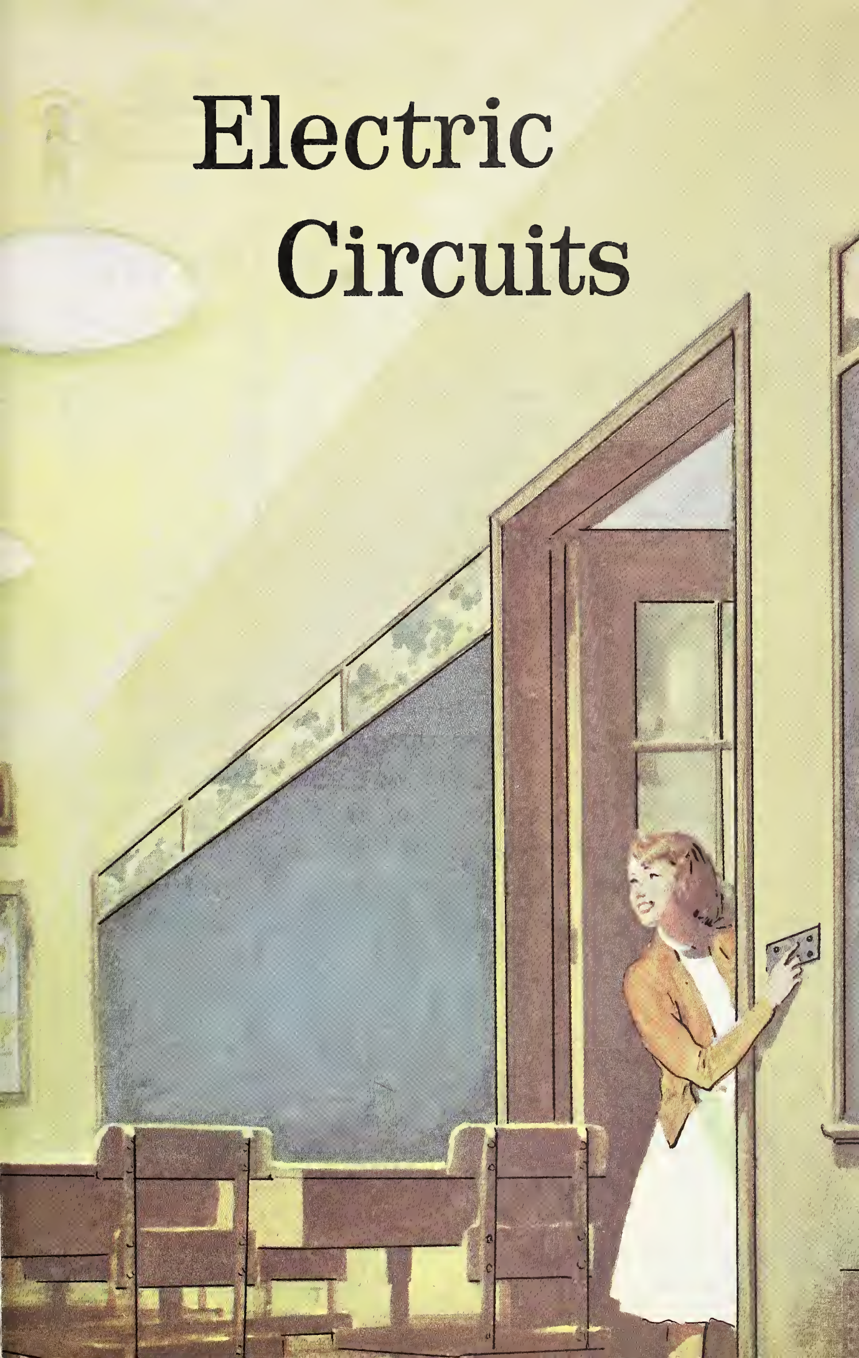
You can see "shooting stars" almost any clear night. They are not really stars at all. Scientists call them **meteors.**

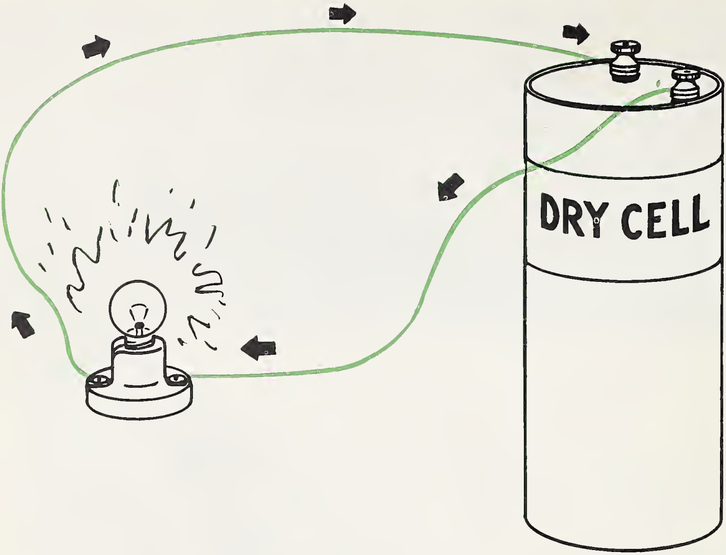
A meteor is believed to be a small rock that came close enough to the earth to be pulled down to it. As it falls, it is heated white hot by the friction of the air. Usually it burns up before it reaches the earth.

---

1. How can you find the North Star?
2. At what time of year can you see Orion in the evening?
3. What star never seems to change its place in the sky?
4. What star can be seen in the daytime?
5. Name some star groups that you can see in both summer and winter.
6. Why do the sun, the moon, and most of the stars seem to move?
7. Which planet do we see as a very bright morning star or evening star?

# Electric Circuits



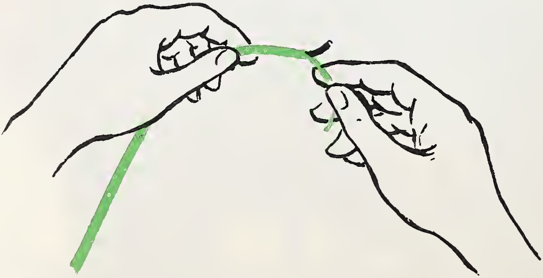


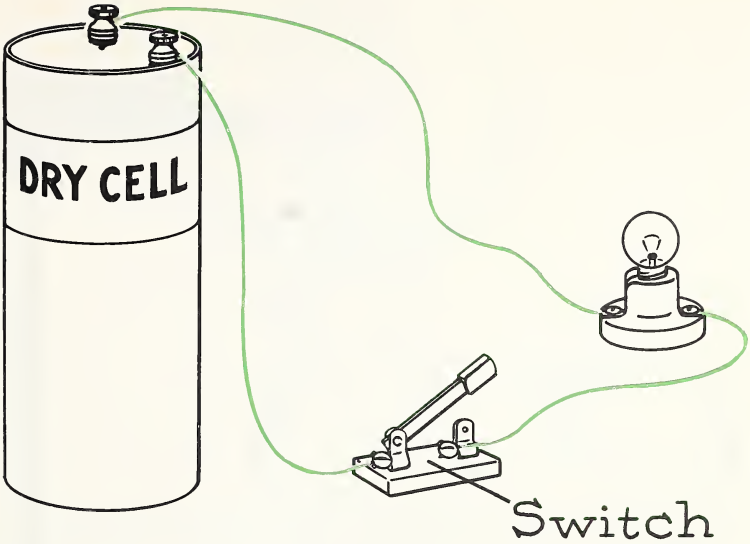
## The Electric Circuit

Two wires go to this lamp. Will it light? Try it. Will the lamp light when only one wire is used? Try it.

The wires, the lamp, and the dry cell make an electric **circuit.** You can move your finger around the circuit and always come back where you started.

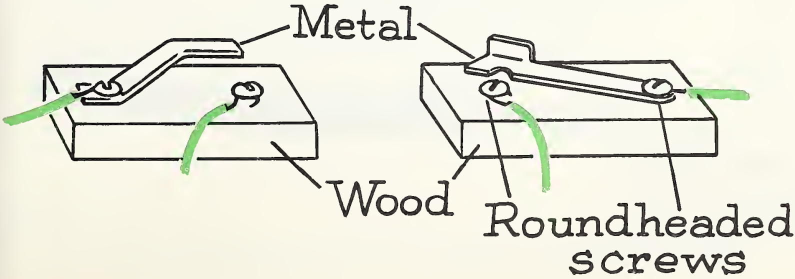
Remember to take the covering from the ends of the wires when you connect the wires to the lamp and the dry cell.

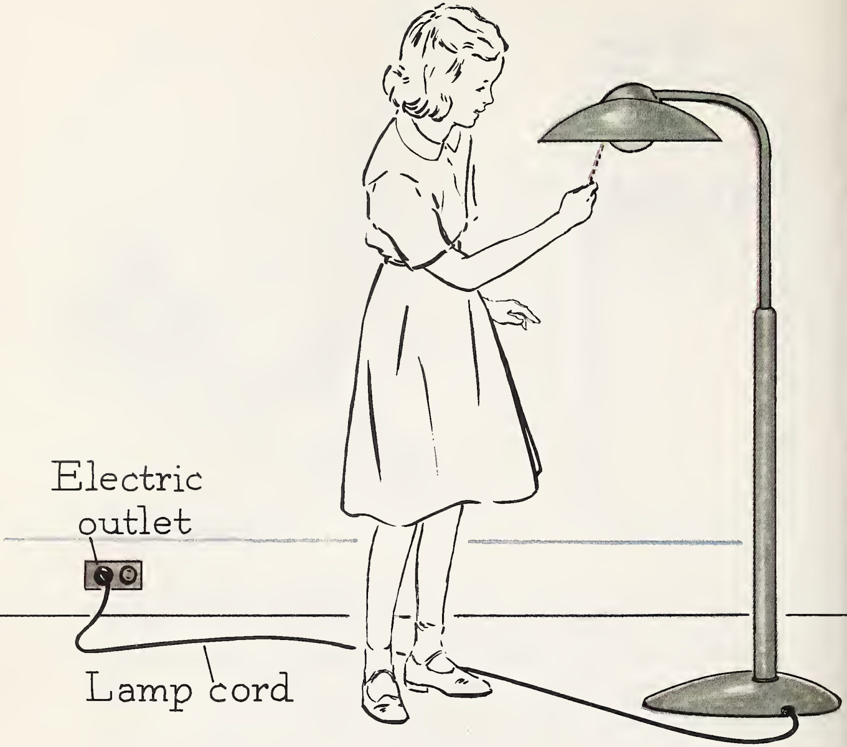




Put a switch in the circuit as shown in the picture. Close the switch. Does the lamp light? Can you follow the circuit with your finger? In the picture the switch is open. This is not a circuit.

Below are pictures of two kinds of switches you can make from the top of a tin can. The switch at the right stays closed or open. The switch at the left stays closed only while you push on it.

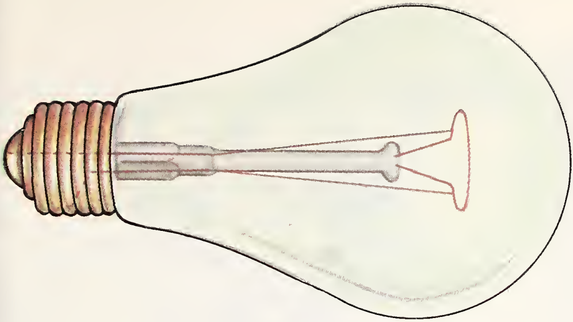


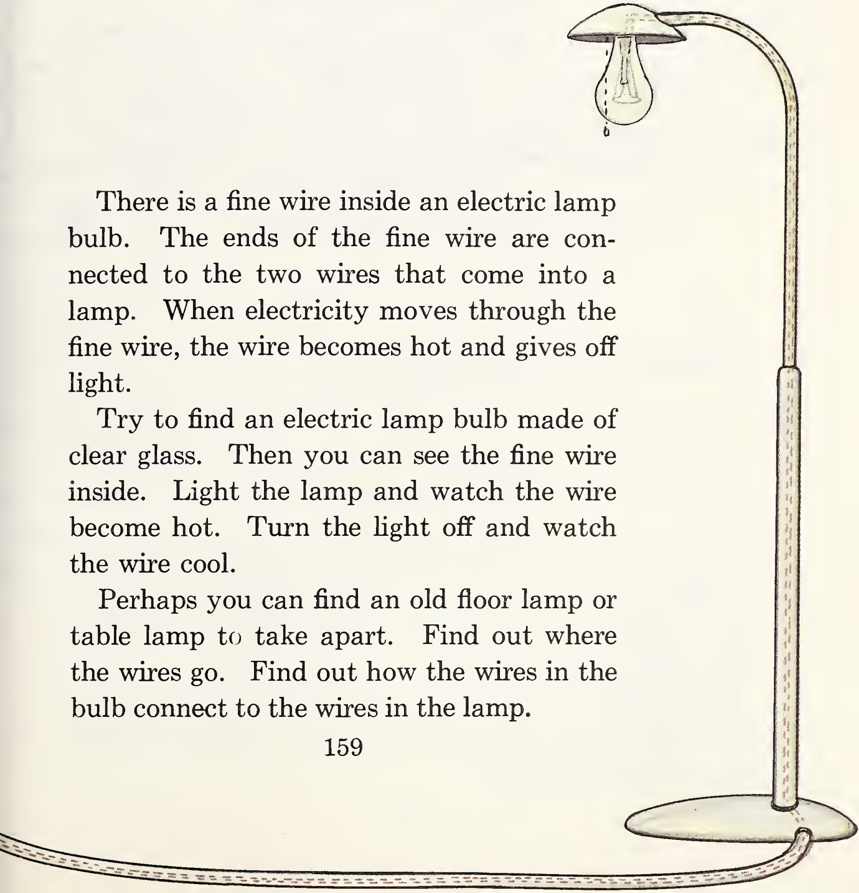


## The Circuit in a Lamp

You might think that there is only one wire going to this lamp. But if you take a lamp cord apart you will find that there are two wires inside it.

Do the wires touch each other?

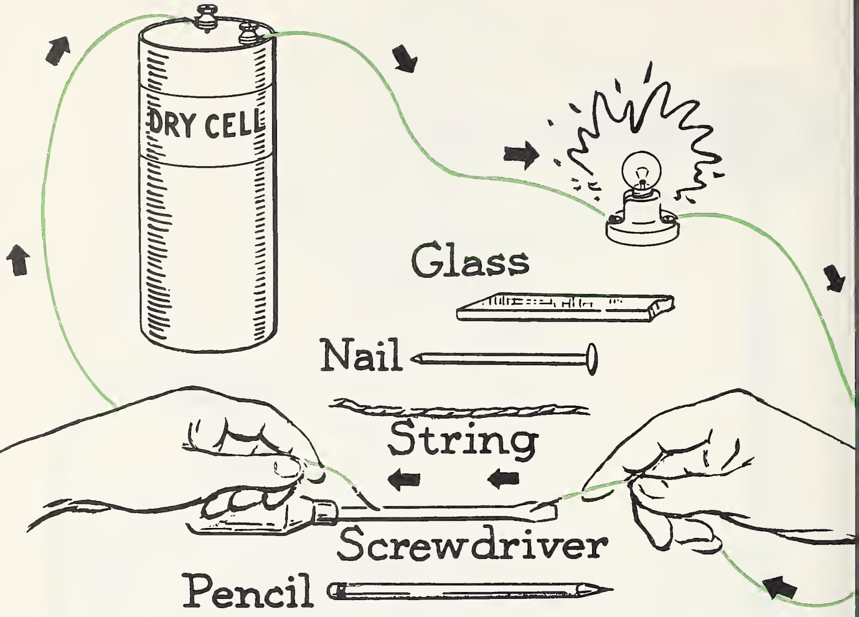




There is a fine wire inside an electric lamp bulb. The ends of the fine wire are connected to the two wires that come into a lamp. When electricity moves through the fine wire, the wire becomes hot and gives off light.

Try to find an electric lamp bulb made of clear glass. Then you can see the fine wire inside. Light the lamp and watch the wire become hot. Turn the light off and watch the wire cool.

Perhaps you can find an old floor lamp or table lamp to take apart. Find out where the wires go. Find out how the wires in the bulb connect to the wires in the lamp.

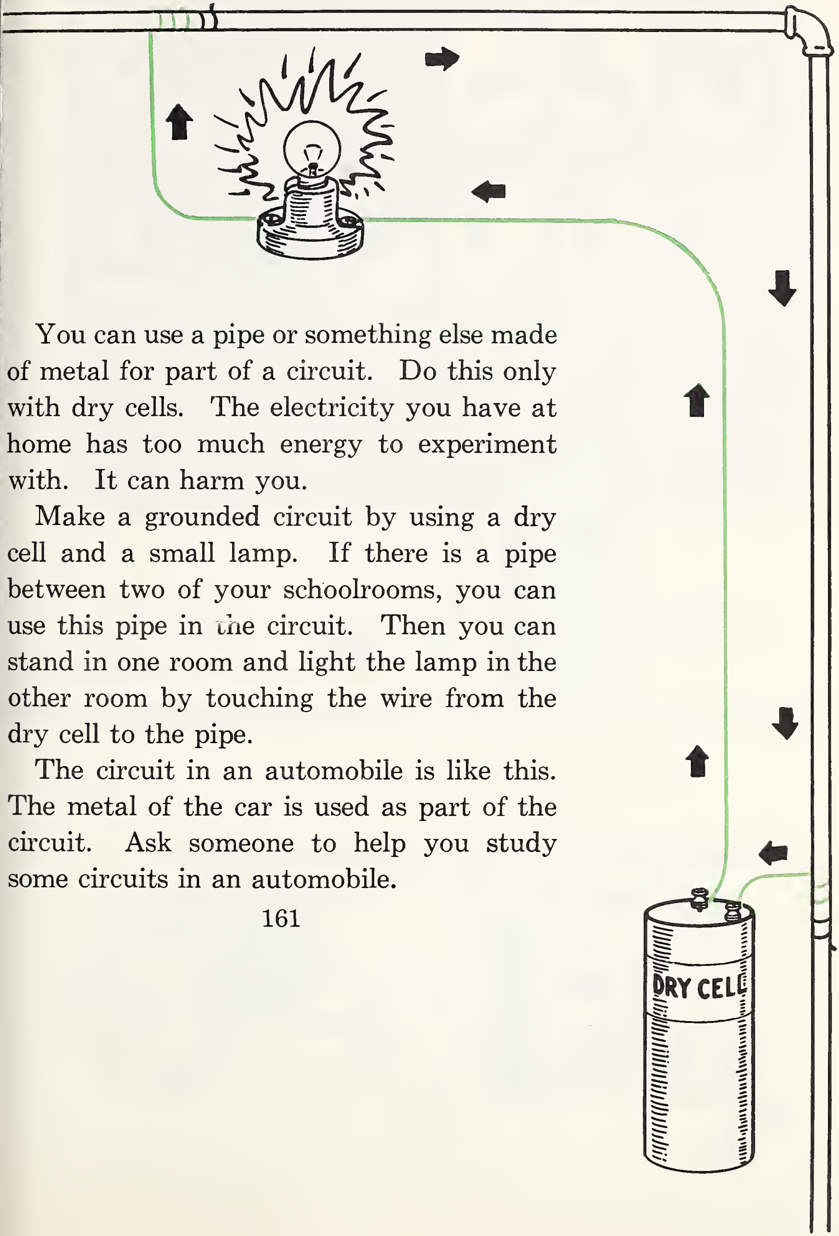


## Conductors and Insulators

Wire is not the only thing that can be used in a circuit. Here we see part of a screwdriver being used. The electricity is able to move through the screwdriver.

Try other things to see if they can be used in a circuit. Try glass, rubber, copper, iron, brick, tinfoil, and wood. Can you find anything made of metal that will not let electricity go through it?

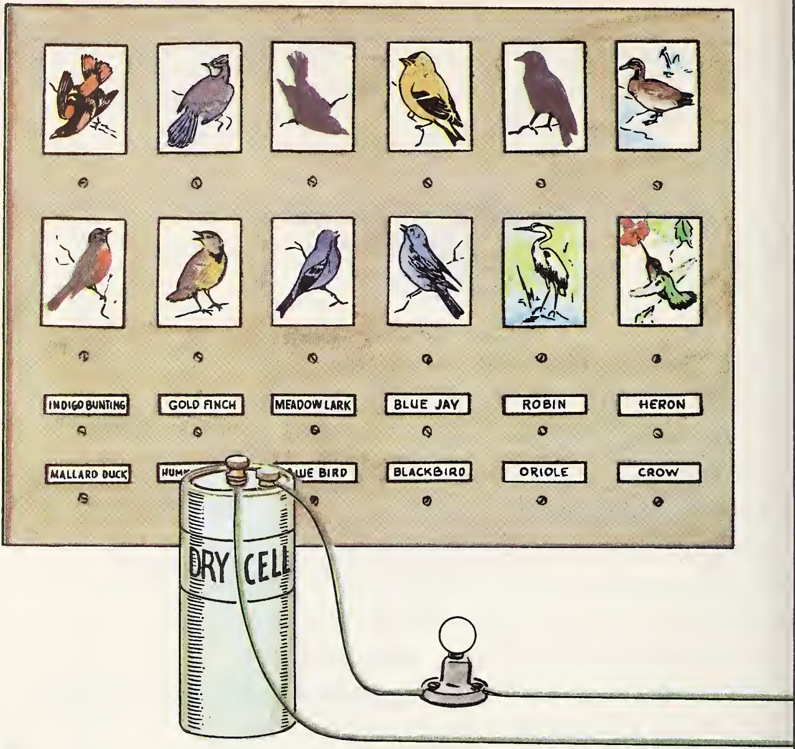
Things that can be used as part of an electric circuit are called conductors. Things that cannot be used are called insulators.



You can use a pipe or something else made of metal for part of a circuit. Do this only with dry cells. The electricity you have at home has too much energy to experiment with. It can harm you.

Make a grounded circuit by using a dry cell and a small lamp. If there is a pipe between two of your schoolrooms, you can use this pipe in the circuit. Then you can stand in one room and light the lamp in the other room by touching the wire from the dry cell to the pipe.

The circuit in an automobile is like this. The metal of the car is used as part of the circuit. Ask someone to help you study some circuits in an automobile.

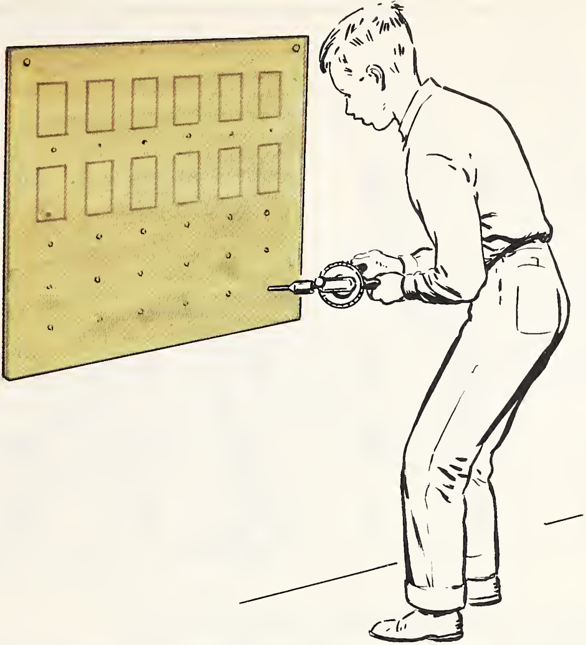


## Making an Electric Question Board

This board can tell whether you know the name of a bird in one of the pictures.

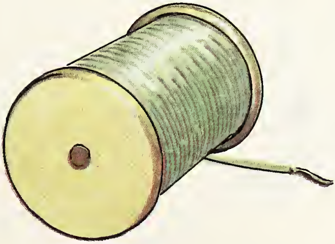
You touch one wire to the button under a bird picture. Then you touch the other wire to the button under the name you think is right.

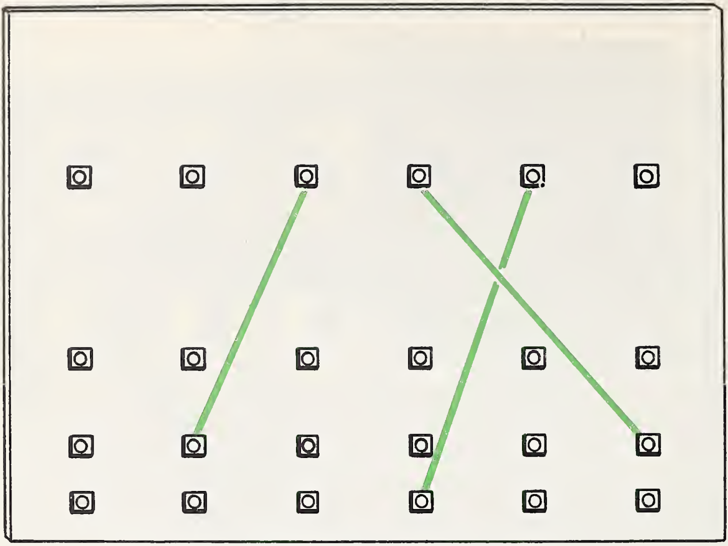
If you have the right name, the lamp will light.



Use a thin board. Mark places for the bird pictures and for the name cards. Then make a hole under each card.

Put a bolt in each hole. Screw a nut on each bolt.

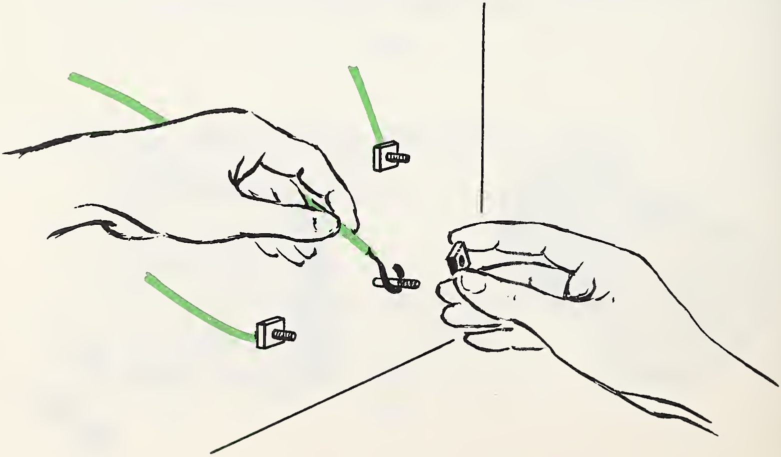


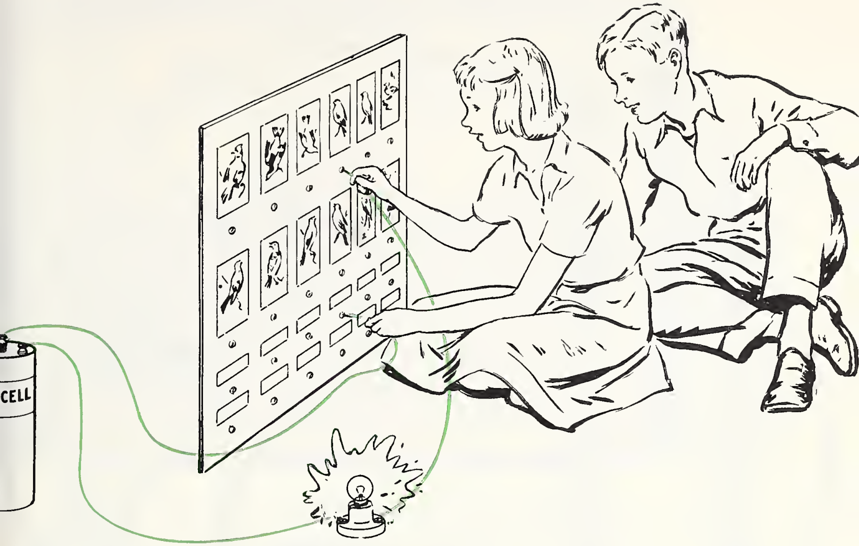


This is the back of the question board.

Fasten a wire from the bolt under a picture to the bolt under the right name.

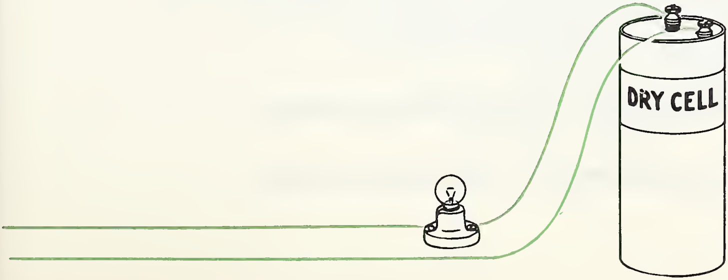
Do this for each picture.

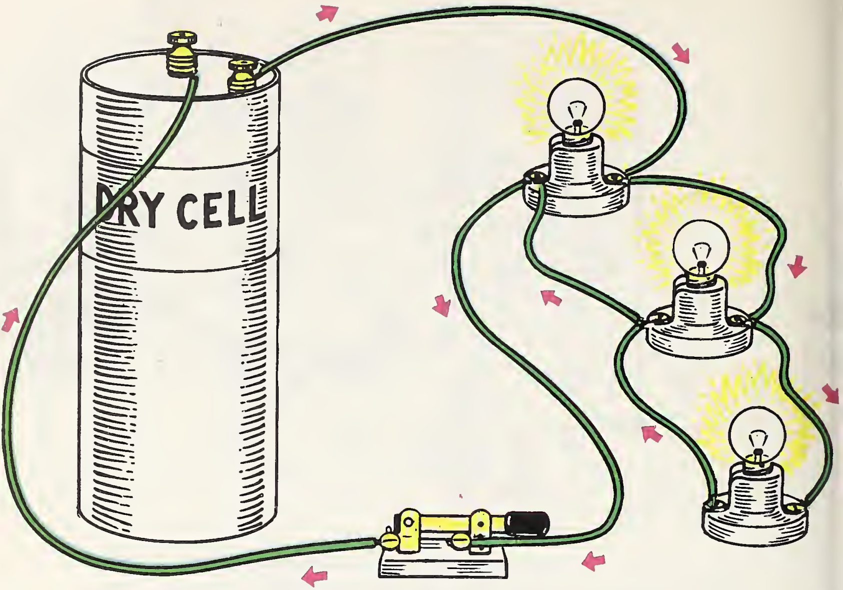




This girl has found the right name for a bird. The lamp has lighted. The wire on the back of the board has made a circuit between the ends of the wires in her hands.

You can use other things on your question board besides bird pictures. You can use pictures of flowers or insects. You can use rocks. You can use a map showing cities or provinces.

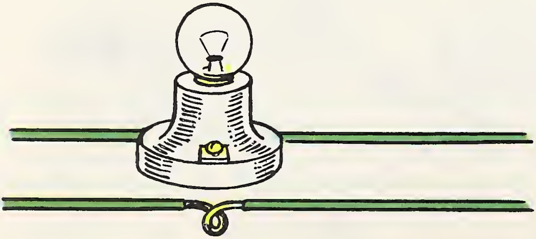


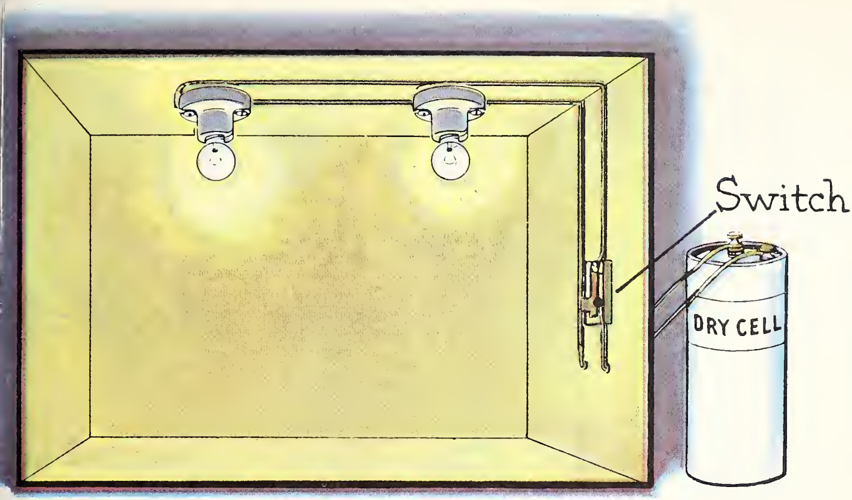


## Lighting Several Lamps

Here is a way to light two or more lamps from the same dry cell. Connect some lamps to a dry cell this way. Do all the lamps light at the same time?

What happens if you unscrew one bulb? What happens if you unscrew two bulbs? If three lamps are lighted, is each one as bright as one lamp used alone?

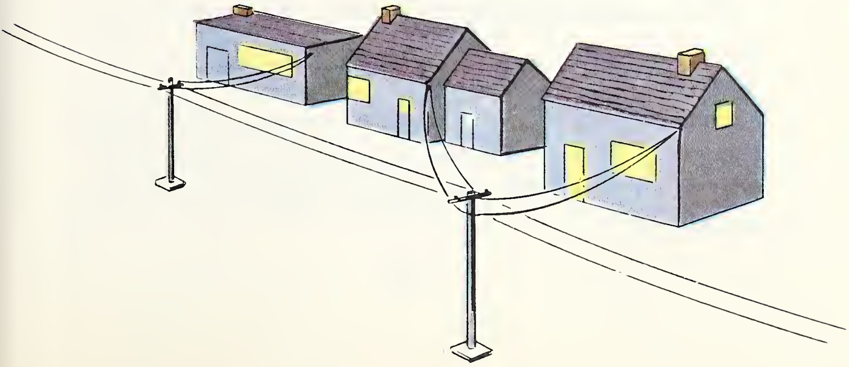


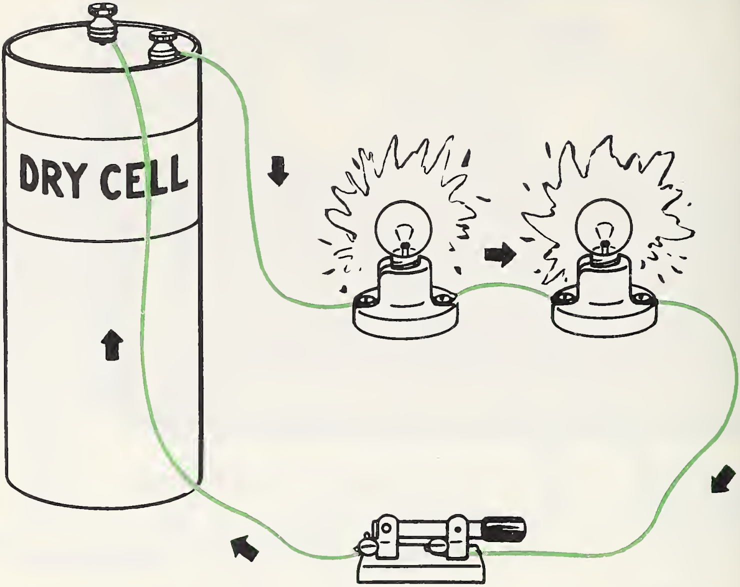


You can put electric lamps in a model house. Use a box for a one-room house. Wire it as shown in the picture. You can use an orange crate for a two-room house.

You can use a switch in each room to turn the lights on and off. Make the switch like the one at the right on page 157.

You can also put electric lights in a model village, a model theatre, or a model airport.

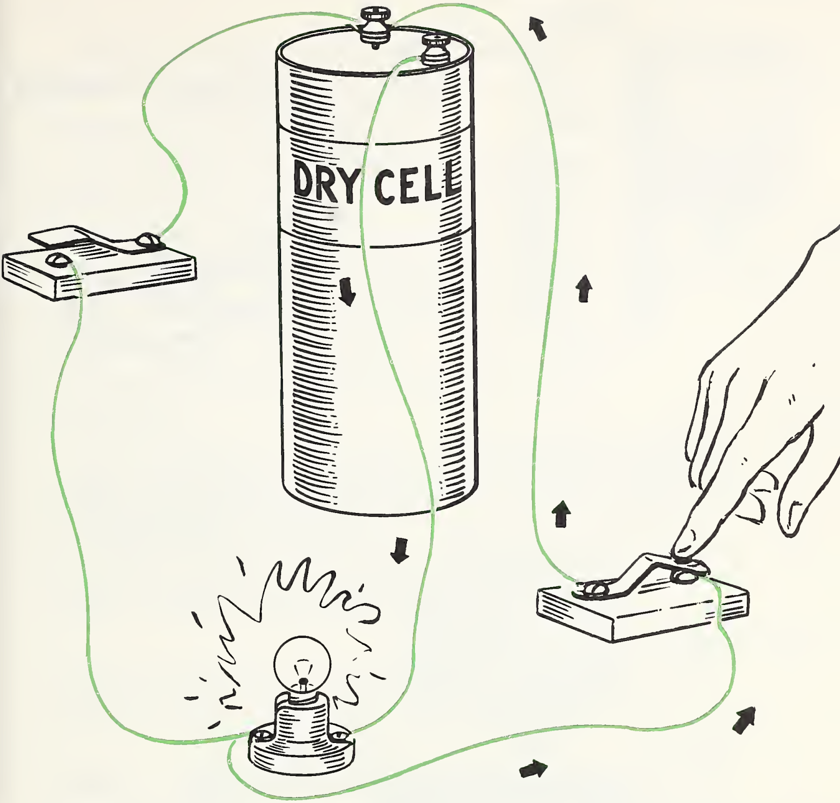




Here is another way of lighting two or more lamps at the same time. Try it. Is each lamp as bright as one lamp used alone? What happens when you unscrew one lamp?

Do you think the lamps in your classroom are connected this way? How do you think they are connected? Why do you think so?

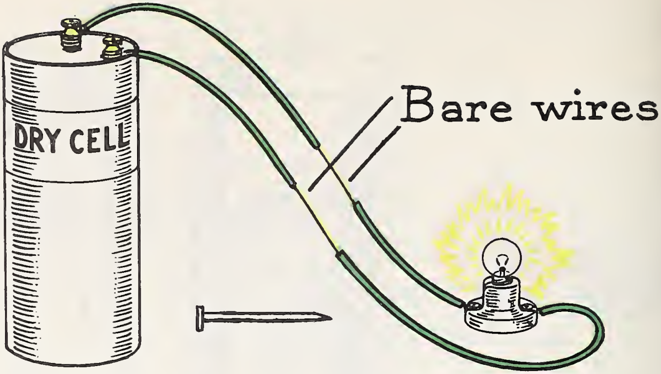
Some strings of Christmas-tree lamps are connected this way. If one lamp burns out, all the lights go out. Then you must test each lamp to find the one that burned out.



## Lighting a Lamp from Two Places

Here is a way you can light an electric lamp from two different places. Follow the circuit when one of the switches is held down.

You can put the lamp in one part of the room and the switches in other parts of the room. You will need long pieces of wire.

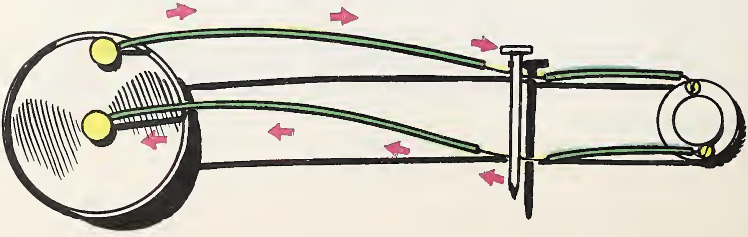


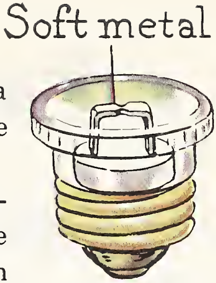
## A Short Circuit

Connect a lamp to a dry cell and take some of the covering from each wire. Touch the bare wires together. What happens to the lamp? What happens to the wires? Lay a nail across the bare places. What happens?

You have made a "short circuit." The picture below shows that most of the electricity stops going through the lamp. It goes by the easier path.

Do not use a short circuit for very long. Much electricity moves through the dry cell and this uses up the dry cell. Why should you always take wires from a dry cell when you are not using it?



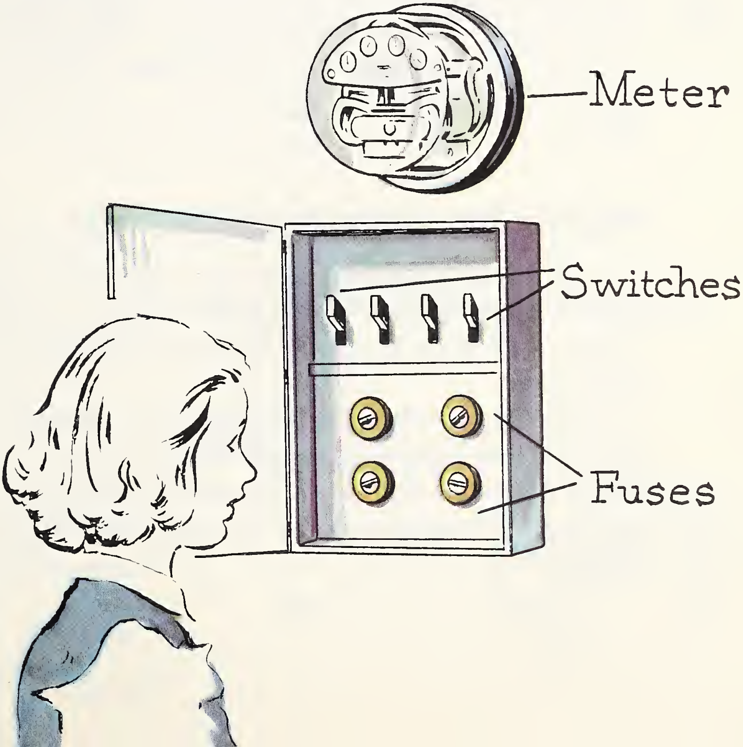


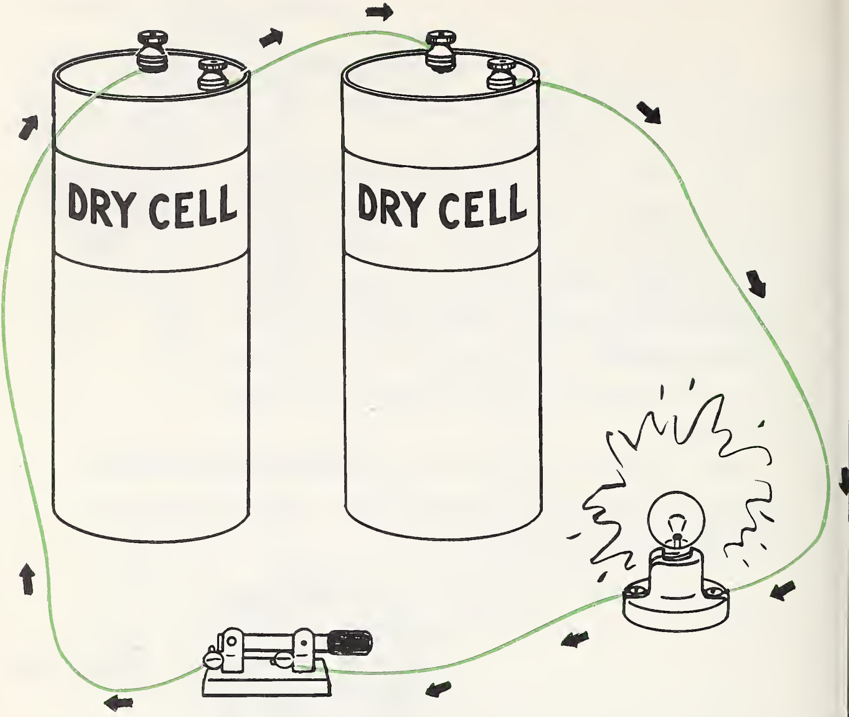
Fuse

Wires become very hot when there is a short circuit. Explain why this can be dangerous in your home.

We protect our homes from being damaged by short circuits by using fuses in the circuits. There is a strip of soft metal in each fuse. If there is a short circuit, the soft metal becomes hot and melts before the wires become hot enough to do harm. When the metal in the fuse melts, the circuit is broken.

Ask someone to show you the fuses in your home. Find out how to put in a new fuse. Look for the strip of soft metal in a fuse.

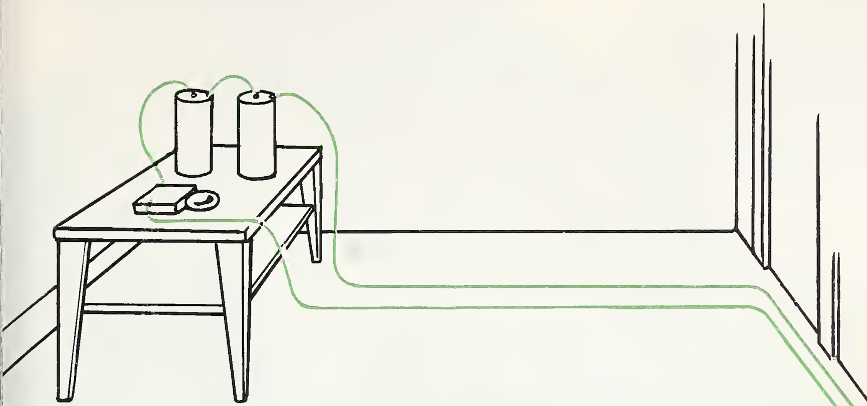




## Making Dry Cells Work Together

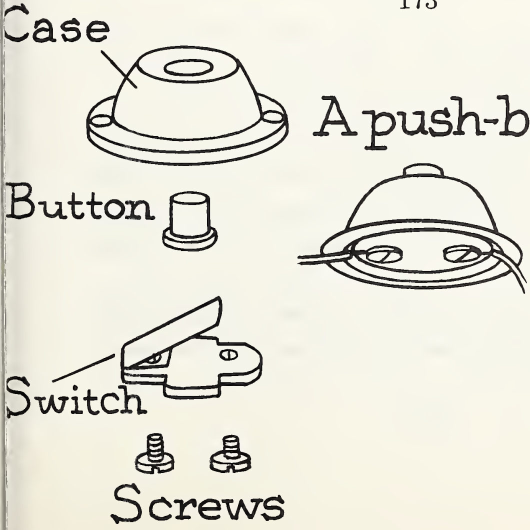
In this picture two dry cells are connected to one electric lamp. Notice the way the dry cells are connected. Follow the circuit by moving your finger along the wires.

Is the lamp brighter with one dry cell or with two dry cells? Two dry cells connected this way give twice as much energy to the electricity as one cell gives. The lamp is brighter because the electricity has more energy.

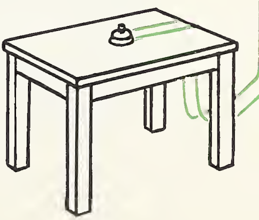


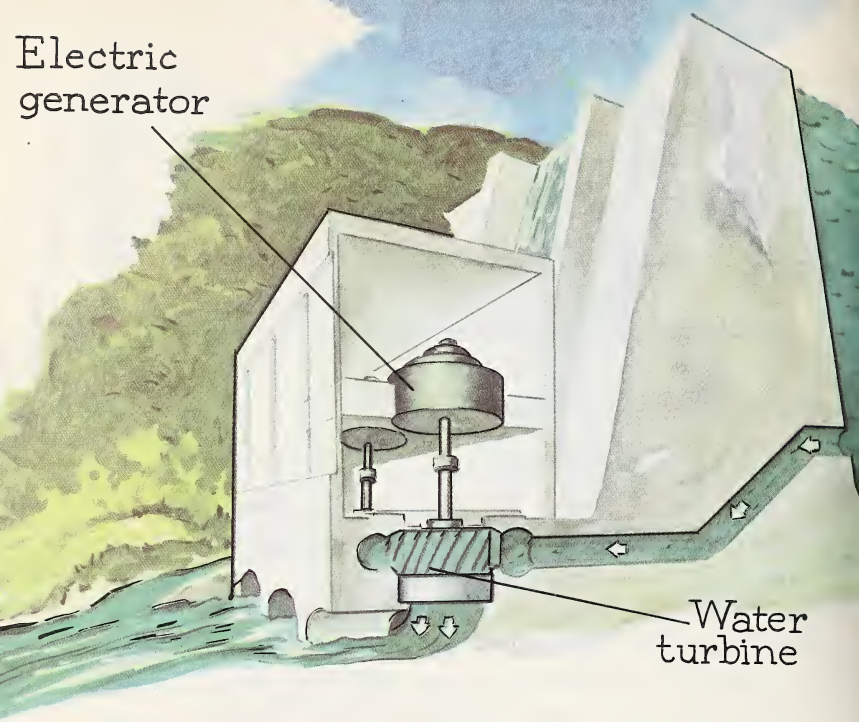
One dry cell may not give enough energy to the electricity to ring a door bell. Two dry cells should be able to make it ring.

This picture shows how to set up a door bell circuit. You may put the table with the push-button switch outside the door of your classroom. The wires can go under the door. Then you can stand outside the door and ring the bell in the room.



A push-button switch



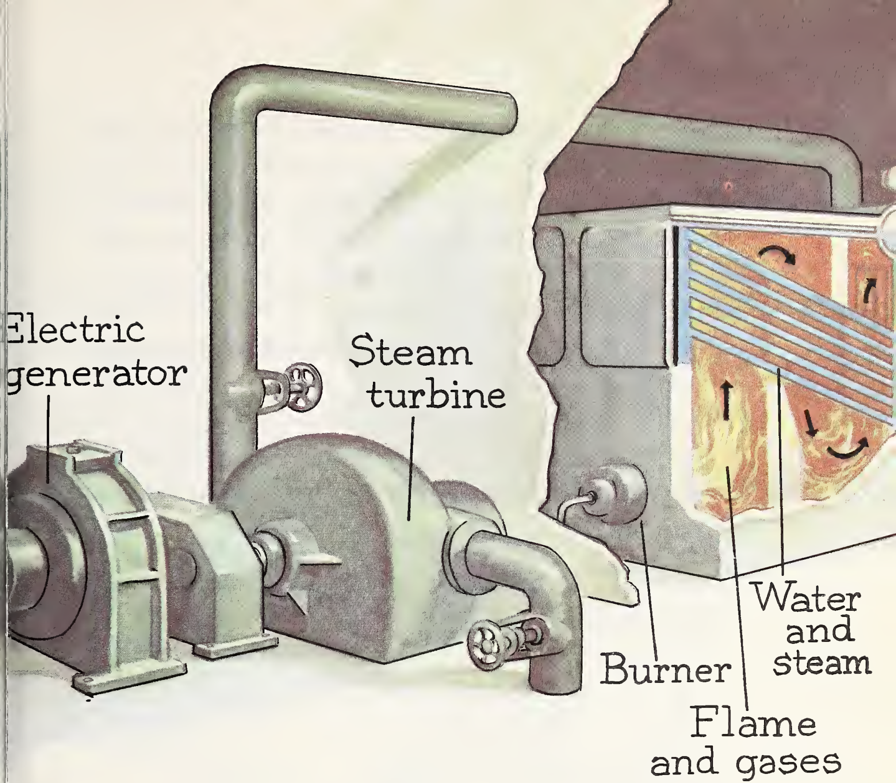


## Where Electricity Gets Its Energy

The electricity you have been experimenting with gets its energy from dry cells. This electricity has very little energy and cannot be used to light our homes.

Much of the electricity we use in our homes gets its energy from falling water. In the picture we see a dam that has made a lake behind it. Water falling over the dam has energy. Some of the water turns water wheels called **turbines.**

Each turbine turns a machine called a **generator.** The generator supplies the electrical energy we use in our homes.



In some parts of the country, steam is used to give energy to electricity. Coal or gas is burned under a boiler. The energy from the fuel changes the water in the boiler to steam.

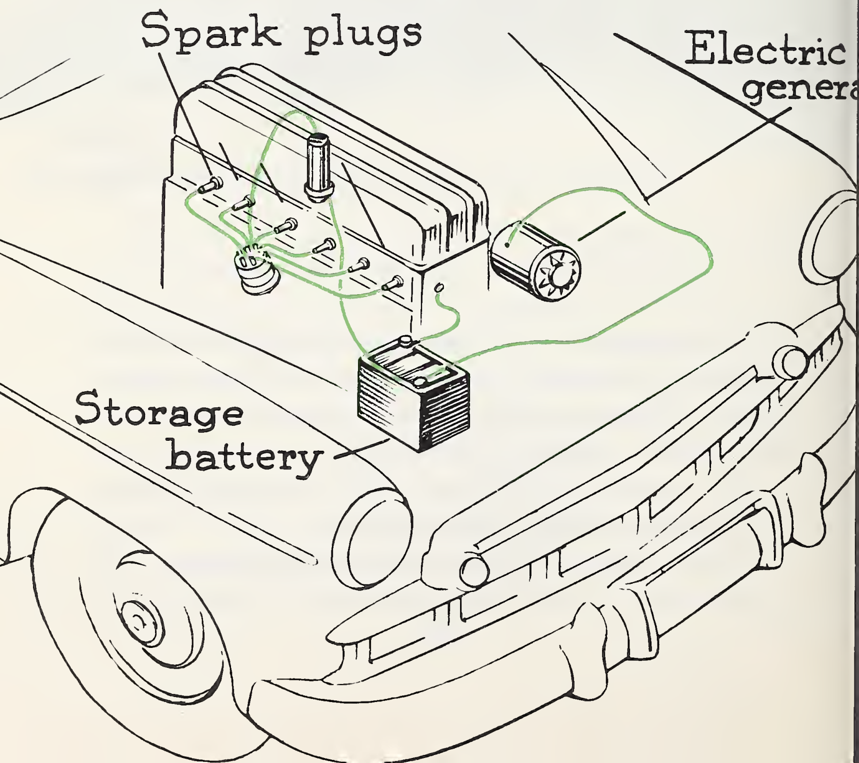
The steam goes through a pipe to steam turbines. The turbines turn electric generators.

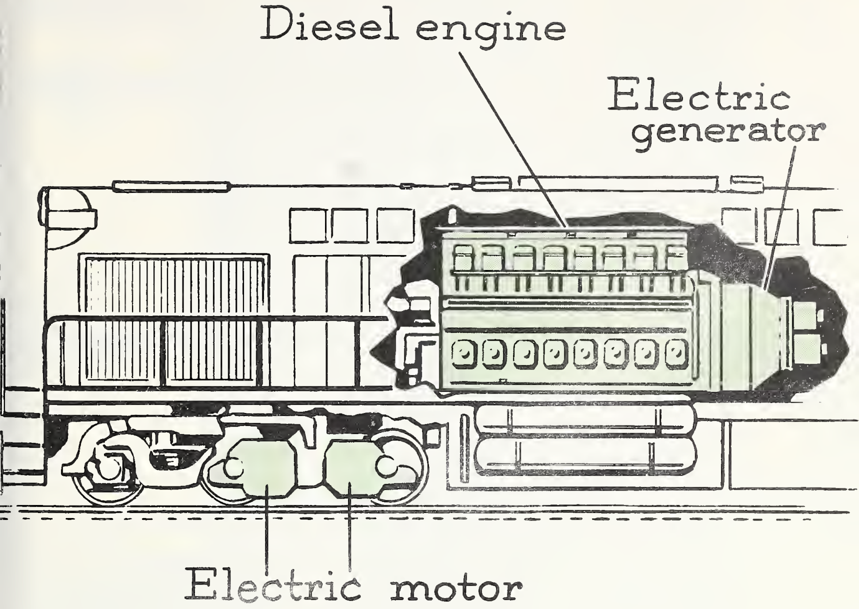
Notice that we do not make electrical energy. We change other kinds of energy into electrical energy.

There is a small electric generator in an automobile. It is turned by the engine. The generator supplies the energy needed for the lights, the horn, and the starter. How else is electrical energy used in an automobile?

There would be no electricity in a parked car if it were not for the storage battery. A storage battery stores extra energy from the generator when the engine is running, and gives the energy back later when the engine is stopped.

Look at the engine of an automobile. Find the generator and the storage battery. What other electrical parts can you find?





Perhaps you have seen railroad locomotives called diesel locomotives. These locomotives are really driven by electric motors.

Diesel engines in the locomotives drive electric generators. The generators supply energy to the electric motors that turn the wheels.

Diesel engines are a little like automobile engines. Instead of gasoline, they use an oil somewhat like the oil used to heat homes. Diesel engines are cheaper to run than gasoline engines.

## High Voltage

Electricity from a dry cell does not have much energy. Its voltage is low. It is safe to experiment with. Electricity in your homes has almost a hundred times as much energy. Its voltage is usually 110 volts. It is not safe to experiment with.

The wires along our streets may carry 4000 volt electricity and the big lines across the country may carry 110,000 volt electricity. Why should you never climb poles that carry these wires?

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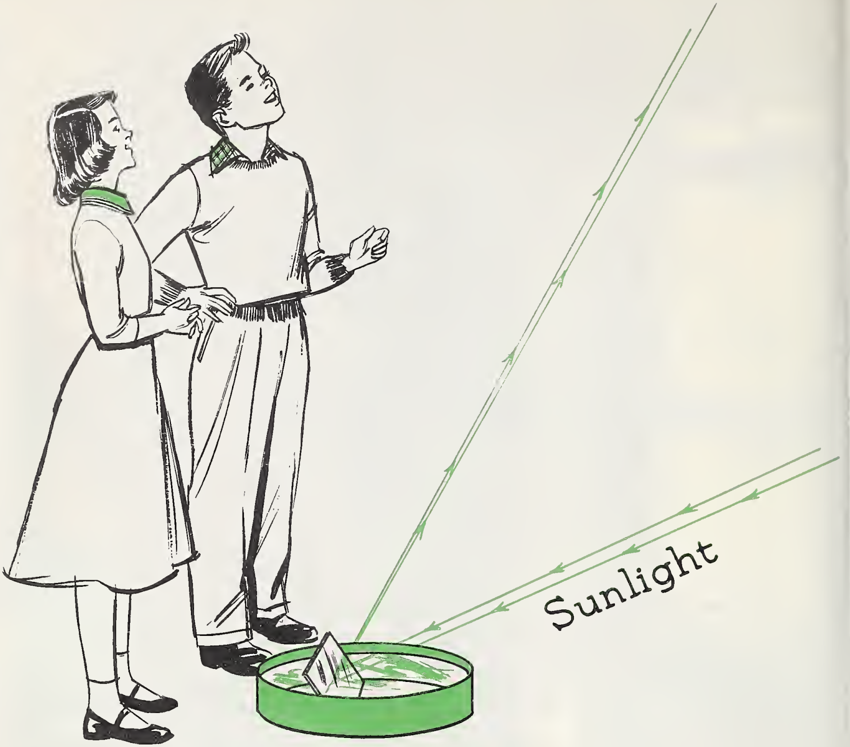
1. What is an electric switch used for?
2. How can you connect two lamps to one dry cell?
3. What may cause a short circuit?
4. How do electrical fuses protect our homes?
5. What are some good conductors of electricity?
6. What is an electrical insulator?

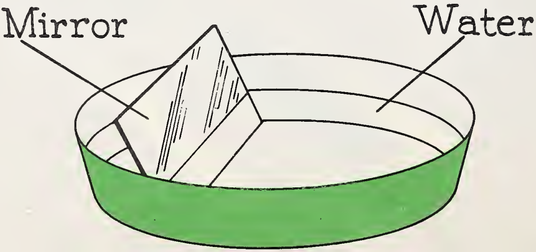
# Rainbow Colours

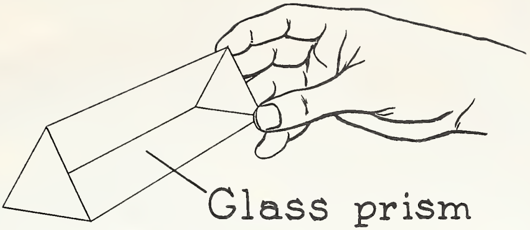


## Making Rainbow Colours

Fill a pan with water and set it on the floor in sunlight. Place a mirror in the pan so that it slants as shown in the picture below.

Wait until the water becomes quiet. Then look at the ceiling. What do you see?

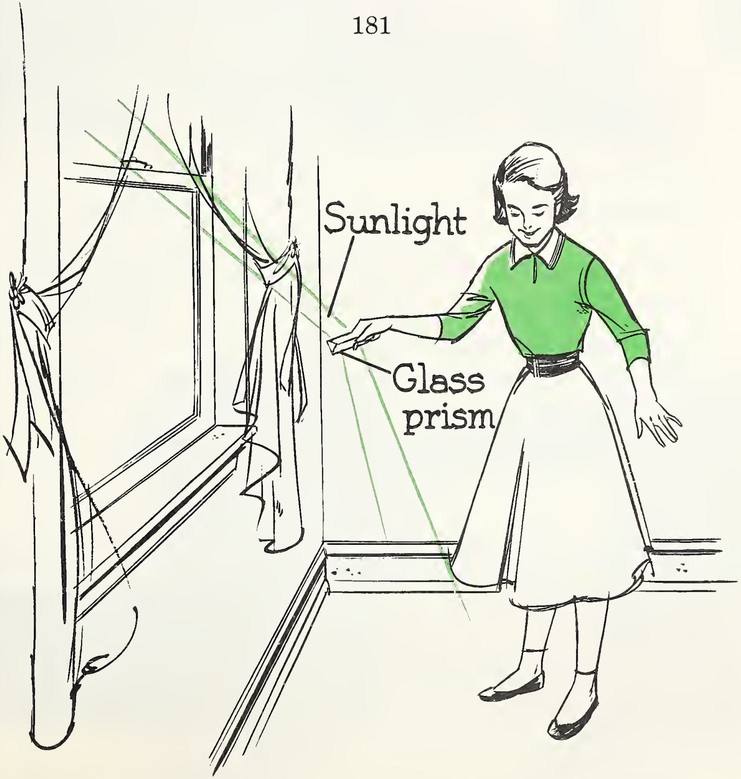


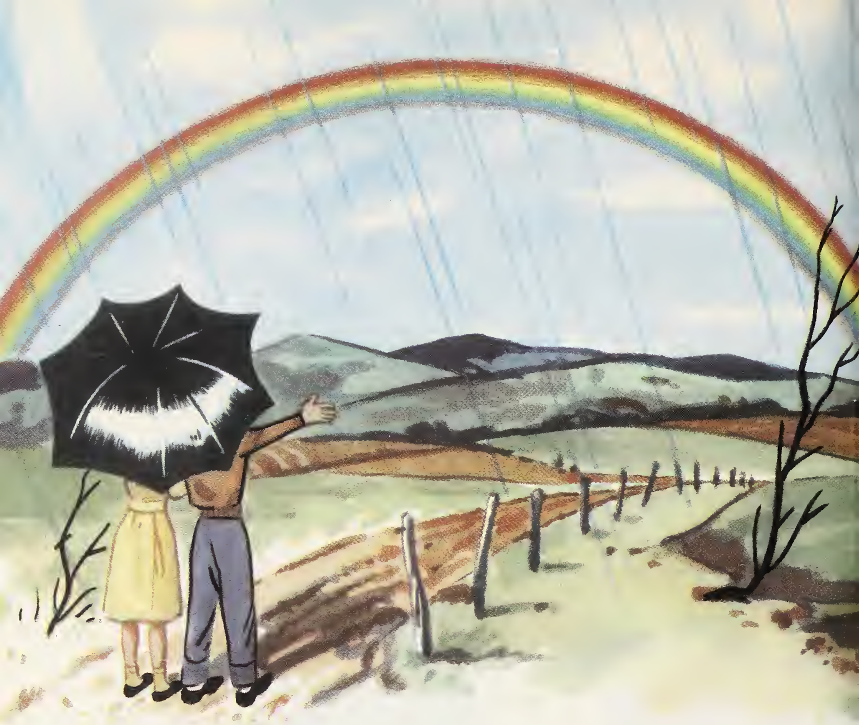


A glass prism will also give the rainbow colours. Stand before a window and hold the prism in sunlight. Turn the prism slowly.

Look at the ceiling. Look at the floor. Where do the rainbow colours show?

What rainbow colours do you see?

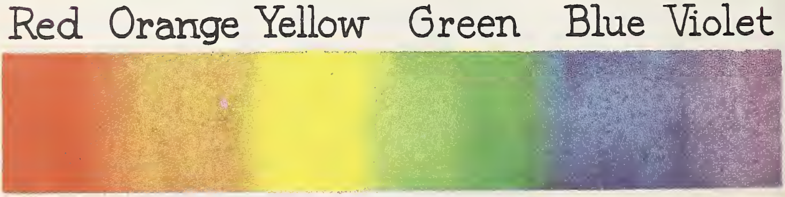




## Rainbows

You sometimes see a rainbow when the sun shines during a shower. Notice the shadows in the picture. Is the sun high or low in the sky? Is the sun in front or in back of the children? You usually see a rainbow only when the sun is low in the sky.

Learn the names of the colours in the rainbow.



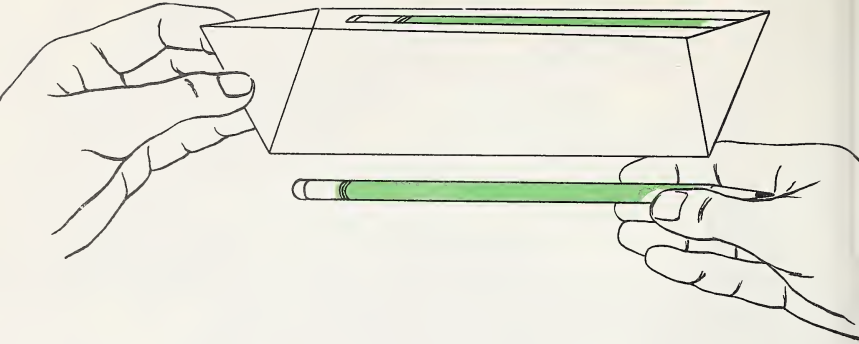
## Spraybows

Fill a spray gun with water. Take the spray gun outdoors in bright sunlight. Make a thick spray. You will see the rainbow colours.

Stand where you can see the colours best. Which colour is on the outside of the bow? Which colour is on the inside of the bow?

You can also make a spraybow with a lawn sprinkler on a sunny day. You can see the spraybow best if there is something dark behind it.

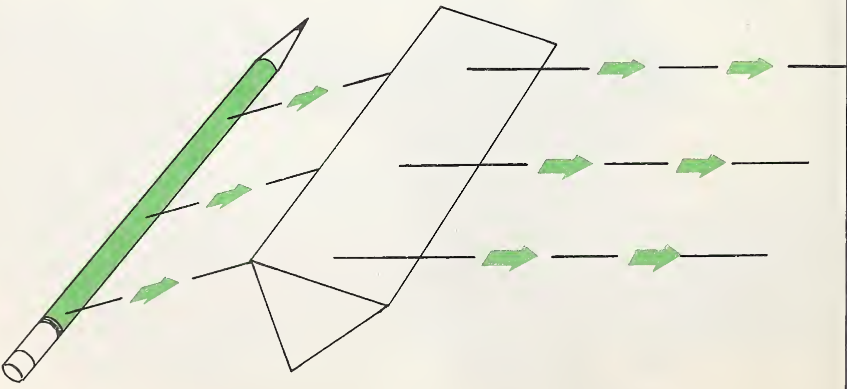
Sometimes you can see a spraybow in the spray from a waterfall.

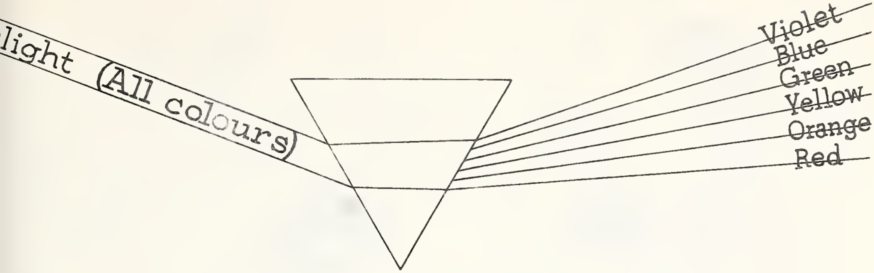


## Bending Light with a Prism

Hold a glass prism with one edge toward you as shown in the picture. Hold a pencil behind the prism and move it up and down until you see the pencil in the prism. Where is the pencil when you see it in the prism?

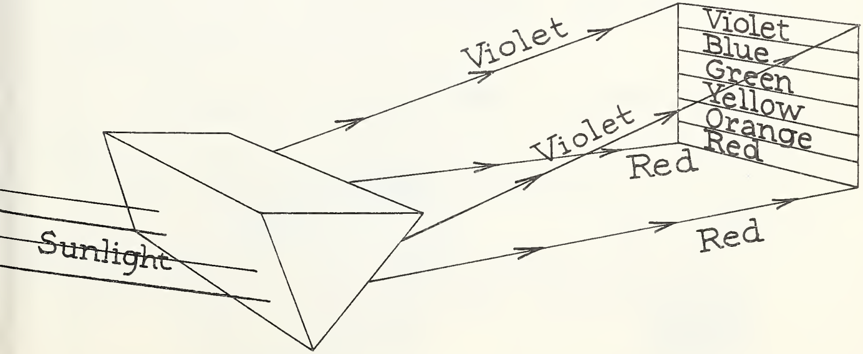
A glass prism bends light. Light from the pencil goes into the prism and is bent as shown below. The pencil looks as though it is behind the prism when it is not.

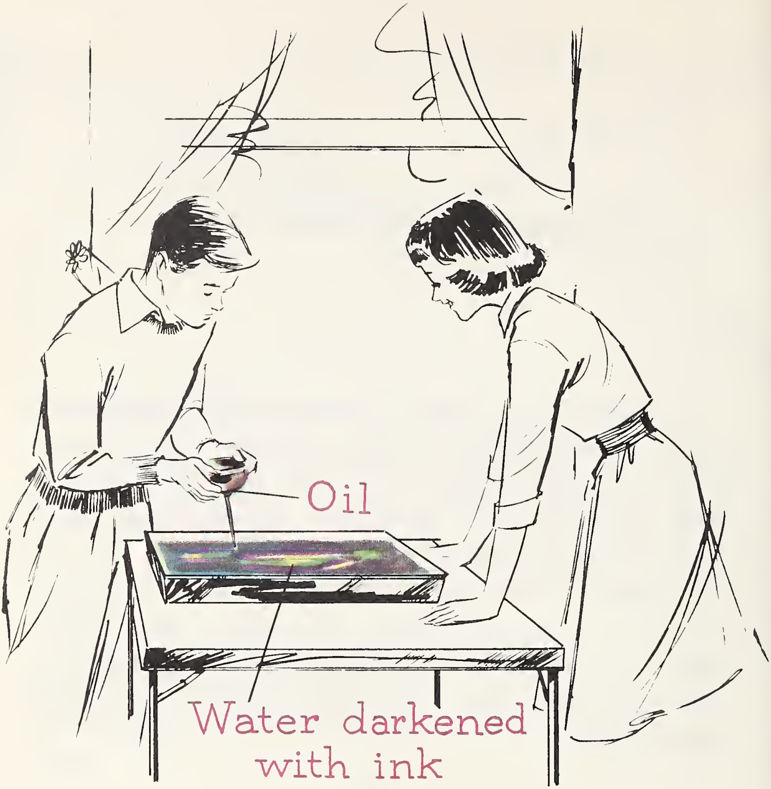




Sunlight is made up of all colours. The colours are separated when the sunlight goes through a glass prism. Rain and other drops of water act like glass prisms. They separate the colours in the sunlight and make rainbows or spraybows.

The colours are separated because some colours bend more than others when they go through a prism. Violet light is bent more than blue light, and blue light is bent more than green light. Red light is bent less than the other colours.

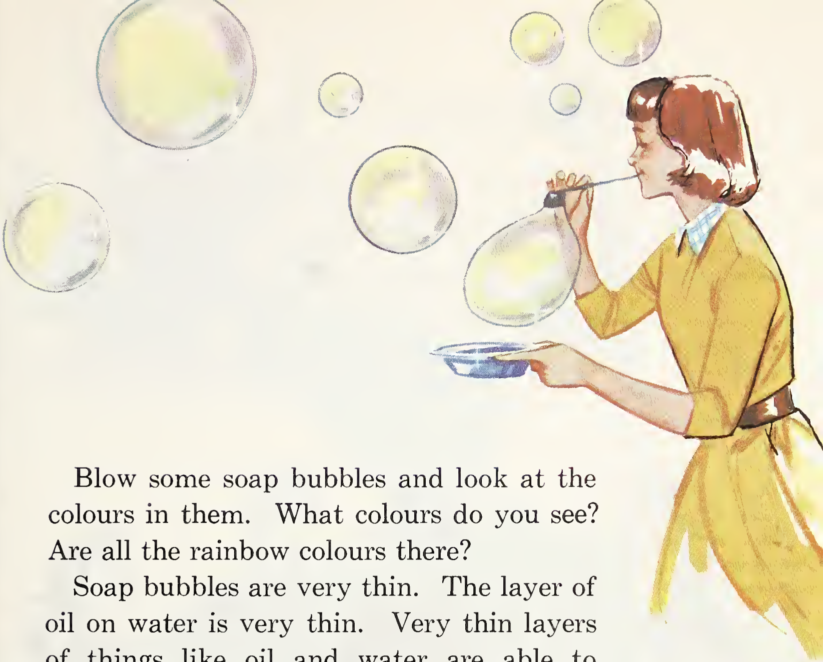




## Other Ways to See Rainbow Colours

Place a tray of water on a window sill where you can see the sky reflected in it. Put some ink in the water to make it dark.

Put a drop of thin oil or kerosene on the water. Step back and look at it. What colours do you see?

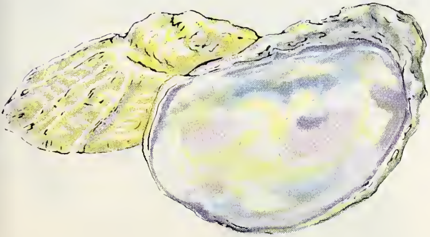


Blow some soap bubbles and look at the colours in them. What colours do you see? Are all the rainbow colours there?

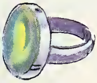
Soap bubbles are very thin. The layer of oil on water is very thin. Very thin layers of things like oil and water are able to separate some of the colours from sunlight.

Some sea shells are made of thin layers and show the rainbow colours. Such shells are often called "mother-of-pearl." Pearls formed in these shells often show the rainbow colours.

Some opals are made of thin layers. Only these opals show the rainbow colours.



Mother-of-pearl



Opal

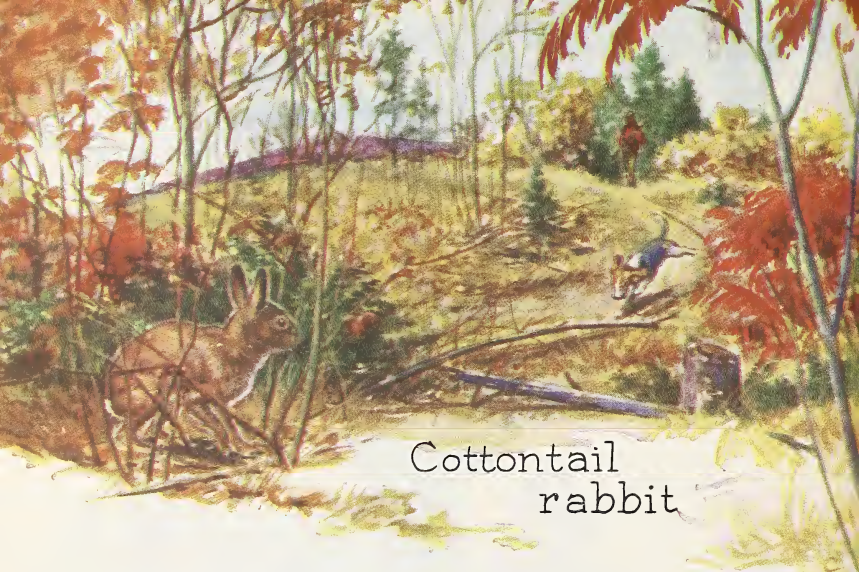
## Colours by Reflection

On a sunny day pull down the shades in all windows except one that has sunlight coming through it. Lay a large sheet of coloured paper in the sunlight. What happens to the colour of things in the room?

Coloured paper reflects coloured light. Green paper reflects mostly green light. Blue paper reflects mostly blue light.

Red flowers look red to us because they reflect red light to our eyes. If the flowers reflect blue light we say that they are blue. What colour of light do leaves reflect?

Sunlight is made up of all the colours mixed together. Our eyes cannot pick out the different colours when they are mixed. We can tell them apart only when they are separated. The colours are sometimes separated by reflection. Does a mirror separate the colours in sunlight?

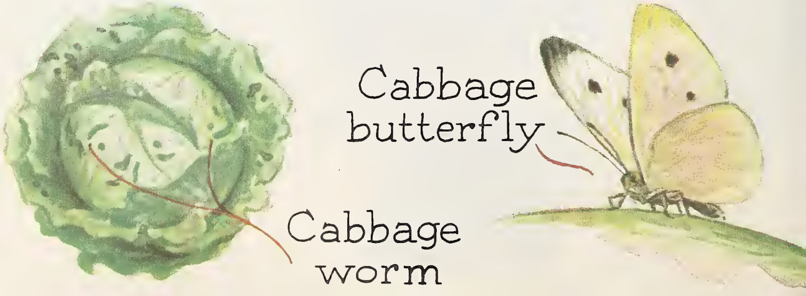


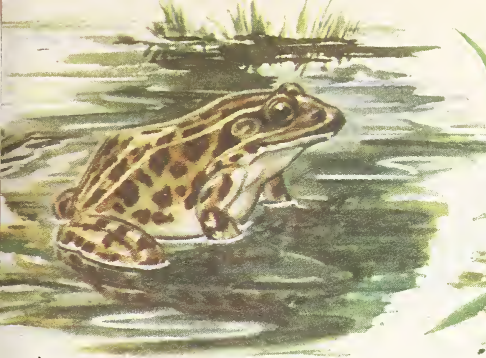
## Colours That Protect

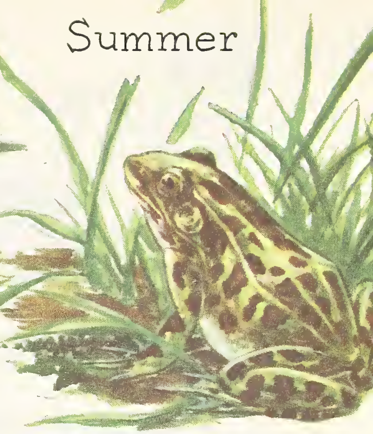
Many animals reflect the same colours as the things around them. These animals are usually hard to see.

Most rabbits are brown like the colour of soil, dead grass, leaves, and twigs. Where do rabbits live? Song sparrows are also brown. Where do song sparrows live?

Many insects that live on leaves are green. The caterpillars of cabbage butterflies are the same colour as cabbage leaves. Tell about other animals that are protected by their colours.



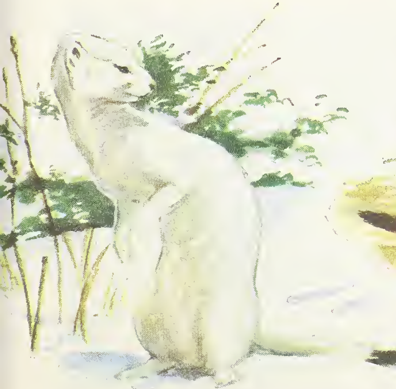

Spring

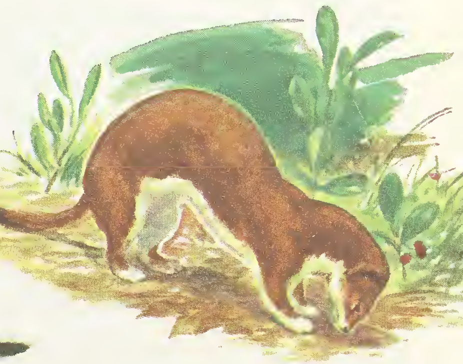

Summer

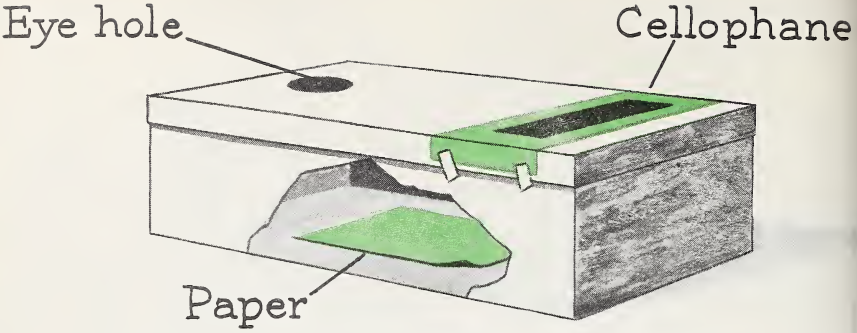
The colours of things where animals live often change with the seasons. It is helpful to the animals if their colours change, too.

Most toads, frogs, and tree frogs change their colours slowly. They can be brown, almost black, gray, or green. Meadow frogs are usually dark in the spring when they are in the water. They turn green when they go to wet meadows for the summer.

There are animals that grow two coats of fur each year. Northern weasels have white hair in winter and brown hair the rest of the year.


Winter


Summer



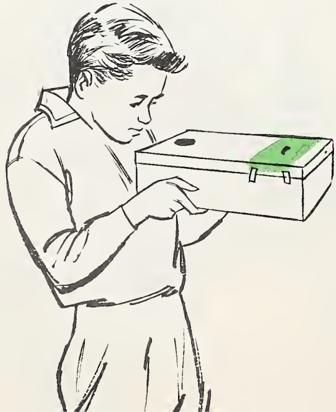
## Experiments with Coloured Light

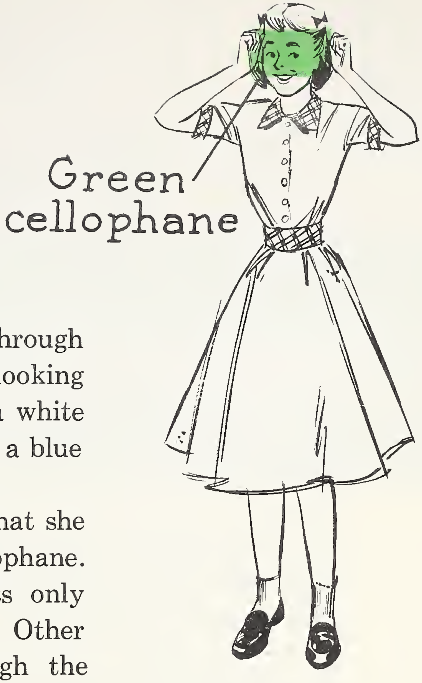
Cut a window near one end of the cover of a shoe box. Cut an eye hole near the other end.

Put a piece of green paper in the box and hold some green cellophane over the window. Look in the eye hole. How does the green paper look in green light? Try paper of other colours.

Hold blue cellophane over the window. Look at paper of different colours. Use red cellophane. Keep a record of what you see.

You will find that white paper reflects all colours. Black paper does not reflect any colour. Can you see colours if there is no light in the box?

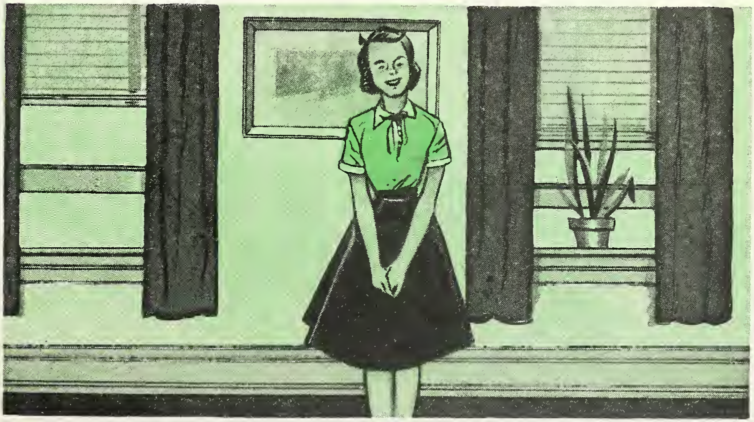




This girl is looking through green cellophane. She is looking at a girl who is wearing a white sweater, a black belt, and a blue skirt.

Below is a picture of what she sees through the green cellophane. The green cellophane lets only green light go through. Other colours cannot go through the green cellophane.

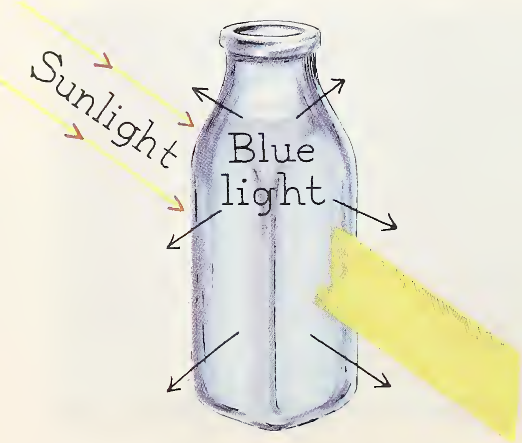
Try this experiment with red cellophane. Try it with blue cellophane.



## Colours in the Sky

People often wonder why the sky is blue. Scientists believe that dust in the air causes the blue colour. They say that dust scatters blue light more than other colours in sunlight. The scattered blue light makes dust and drops of water in the air look blue.

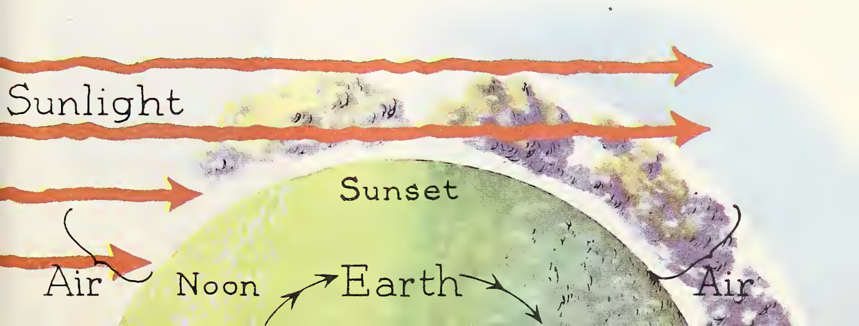
Put a teaspoonful of milk in a quart bottle of water. Look through the water toward the sun. Look at the water from the side. The tiny drops of milk scatter blue light from the beam of sunlight. Perhaps the blue light in the sky is scattered the same way.

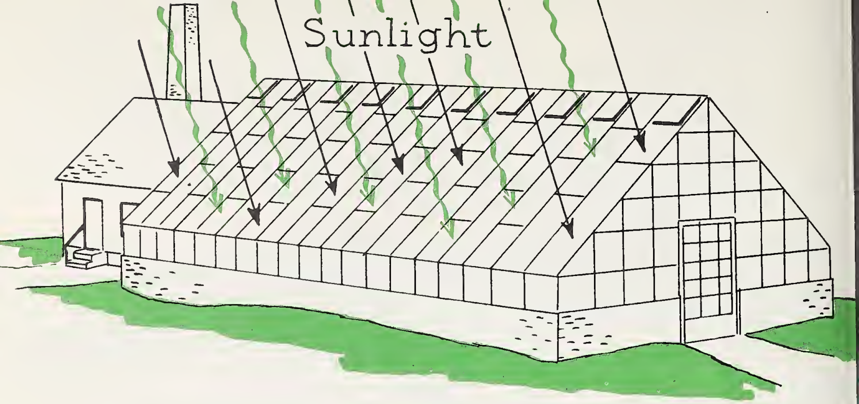


People also wonder about the colours they see at sunrise and at sunset. The colours are more beautiful after dust storms, so we think that dust causes these colours too.

The picture below shows that the sun shines through much more air at sunrise and at sunset than it does at noon. Dust scatters out much of the blue colour. The red light comes through.

Watch for one of these sunsets. Notice how red the light is. White houses look pink. How does grass look?



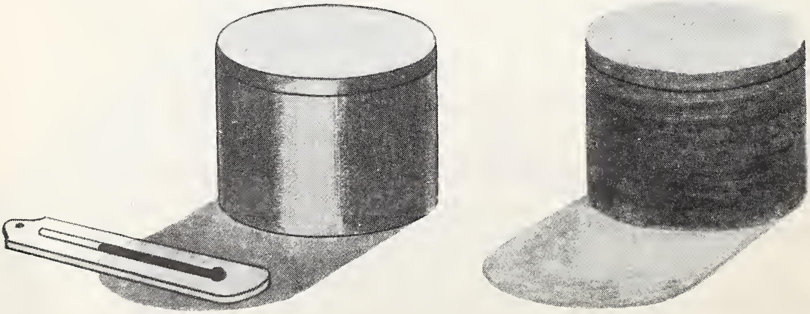


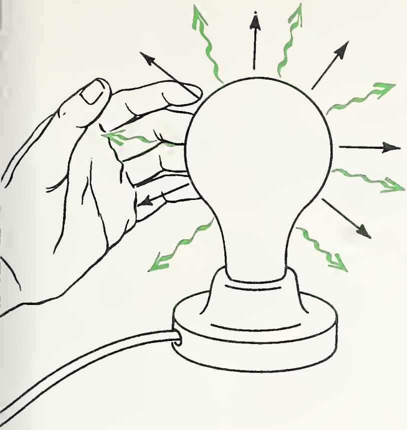
## Invisible Light

There are colours in sunlight that our eyes cannot see. One of these colours is almost red. It is called **infra-red.** Cameras can take pictures by this colour.

Infra-red light makes us feel warm when it shines on us. It can go through window glass in greenhouses and make the soil inside become warm.

Infra-red light can also be reflected. Find two metal cans and paint one of them a dull black. Put the same amount of water in each one and put on their covers. Set both cans in sunlight for an hour and then take the temperature of the water in each. Which is warmer?

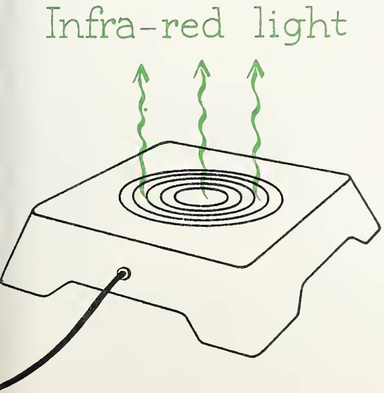


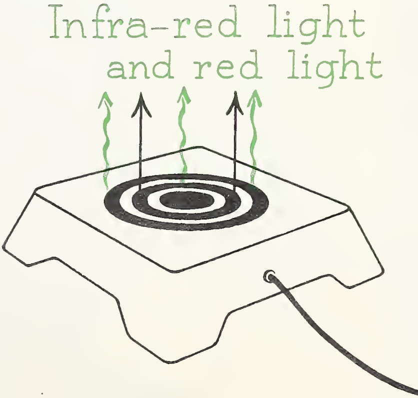


Hold your hand near an electric lamp and then near a can of hot water. You will feel a warmth from each. The lamp gives off visible light and infra-red light. The can gives off only infra-red light. All hot things give off infra-red light.

Turn on an electric hot plate. At first you will feel a warmth but you will see no light. As the burner becomes hotter it gives off both infra-red light and red light.

The wire in an electric lamp becomes very hot. It gives off infra-red light and all colours of visible light mixed together.





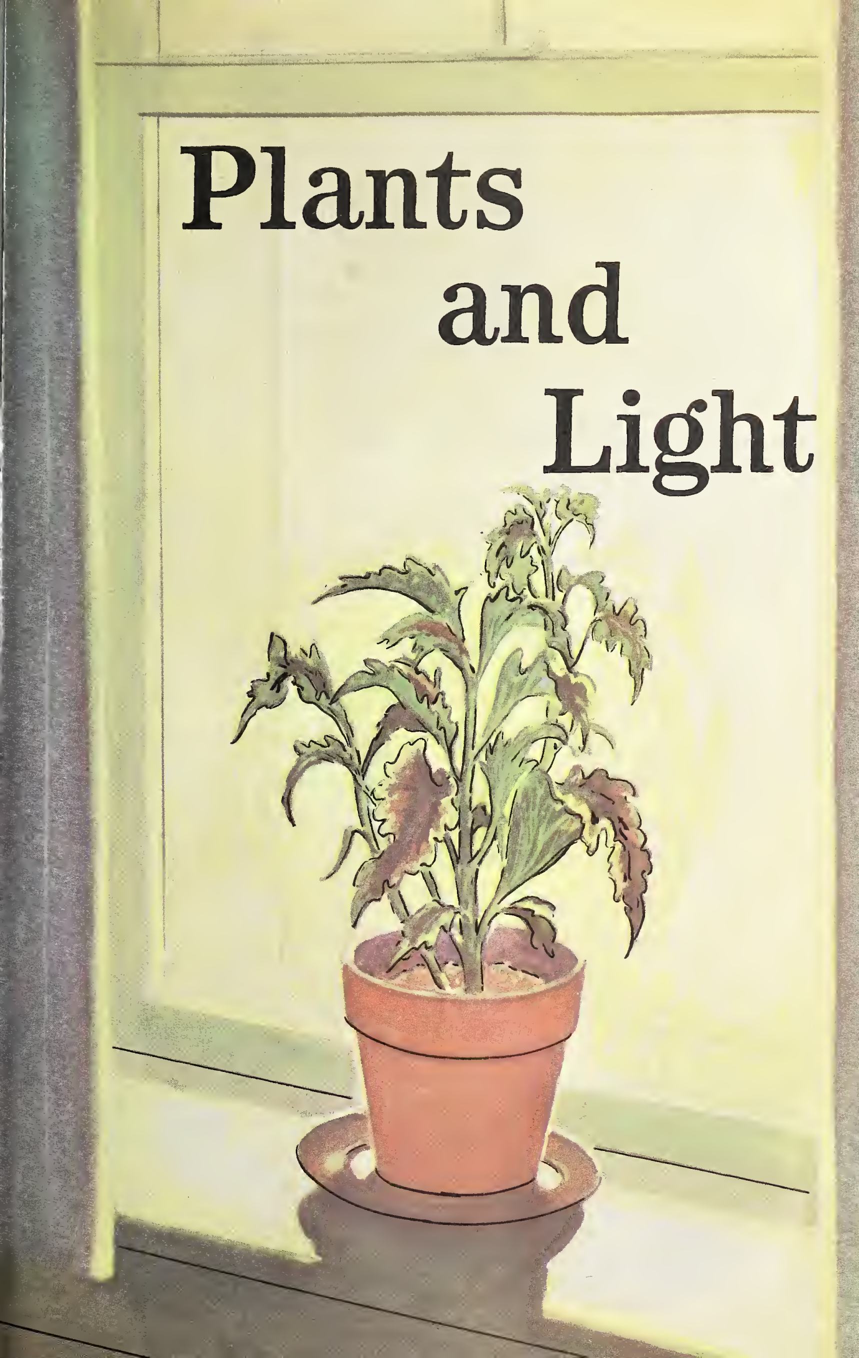
Some of the invisible light in sunlight is almost violet in colour. It is called **ultra-violet**. Ultra-violet light on our skin helps us make Vitamin D, which we need for good health.

Ultra-violet light changes the skin of many people to a brown colour. Too much of it at one time, however, can cause a sunburn.

---

1. What are the colours of the rainbow?
2. What does a glass prism do to sunlight?
3. When can you see a rainbow?
4. Why does a flag look red, white, and blue?
5. What colours are reflected from white paper?
6. How are some animals protected by their colour?
7. What colours can you see through green cellophane?

# Plants and Light



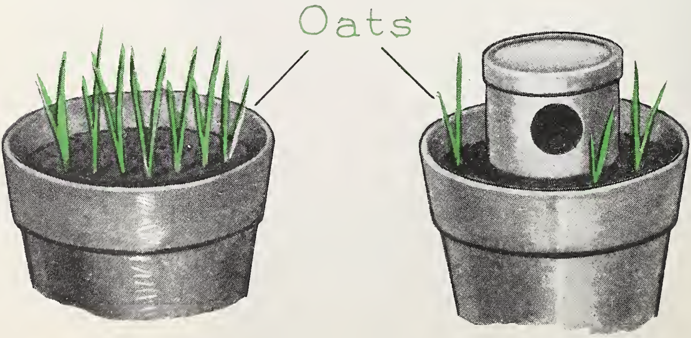
## Light and Plant Growth

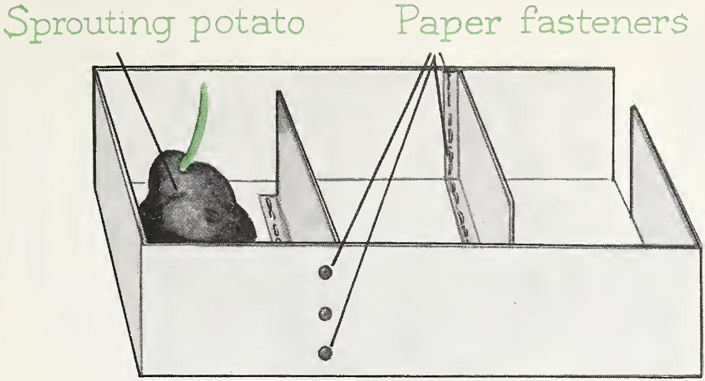
A house plant on a window sill grows toward the light. Here is an experiment to help you find out whether other plants grow toward the light.

Plant some oats in each of two pots. Cut a hole in one side of an ice cream container. After the oat plants are about half an inch high, put the container over the plants in one pot.

Look at the plants a few days later. Turn the container half way around. Look at the plants after a few more days. Try other kinds of plants.

Find out whether the plants always grow toward the light.

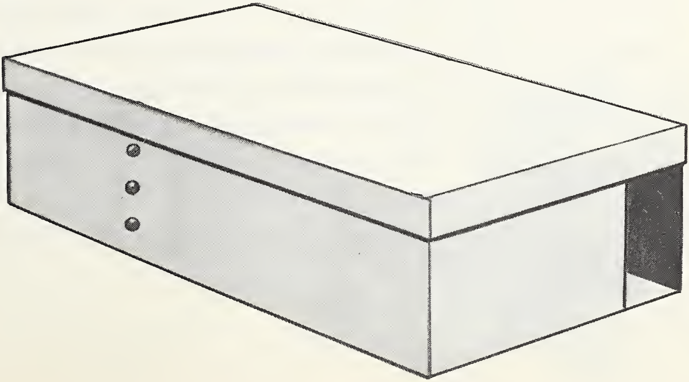




In this experiment you will find out whether a sprouting potato grows toward the light. Cut a hole in one end of a shoe box. Fasten pieces of cardboard part way across the inside of the box.

Put a sprouting potato in a dish of moist soil and set the dish in the dark end of the shoe box. Put the cover on the box and set it on the window sill.

Look at the potato sprout every day. Notice how it grows. Does it grow toward the light?



Perhaps you can visit the edge of a woods and study the way the trees grow. Notice how they grow out toward the open. Notice that the branches on the side toward the woods are usually smaller and have fewer leaves than the branches on the open side.

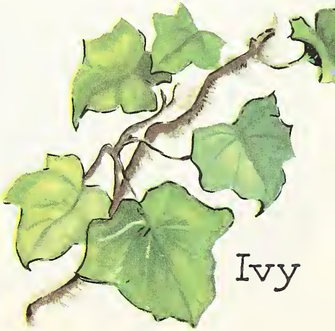
Look at small trees and large bushes growing close to buildings. Often these plants grow larger on the side away from the building.

Make drawings of some of the trees that are growing toward the light.

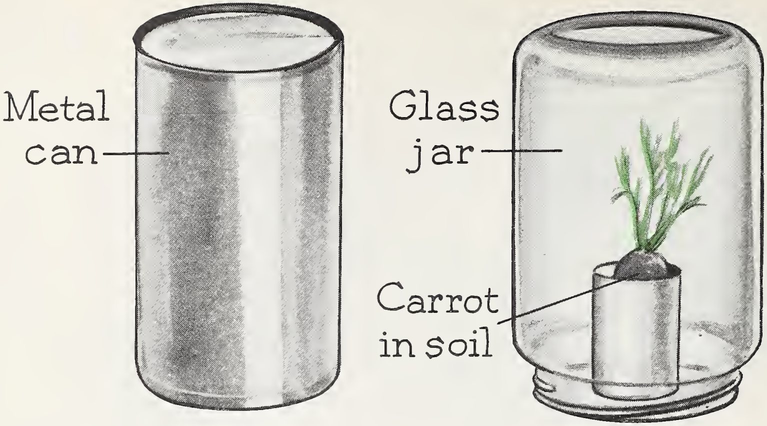
Perhaps you can also study a vine growing on a wall. Are there many bare places between the leaves? Do some of the leaves cover other leaves? Are some leaves so well covered that they get little light?

The leaves of vines do not usually cover one another. If a leaf is covered, it grows toward the light. If it cannot get enough light, it does not grow well and it often dies.

Ivy is a vine which often grows on buildings. Try to find out the names of the vines that you have been studying.



Ivy

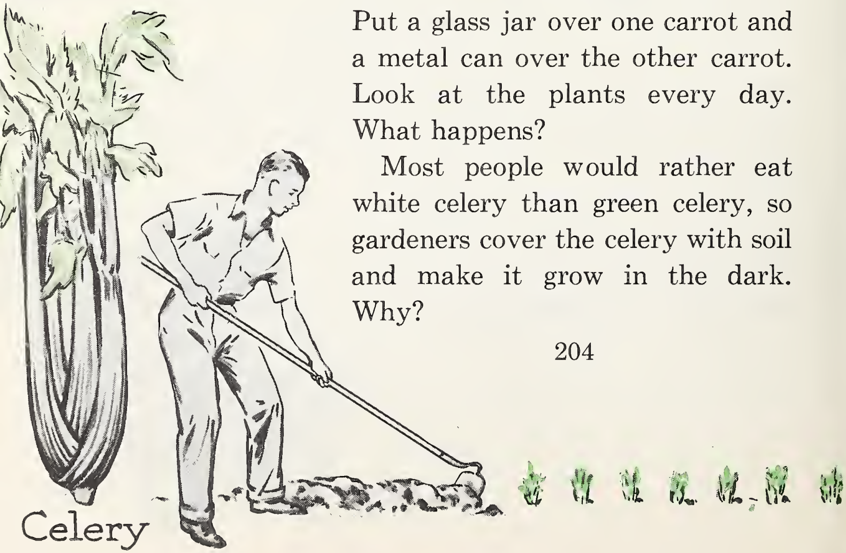


## Light and the Colour of Plants

Did you ever pick up a board that had been lying on the grass for several days? Did you notice that the grass under the board was light green or even yellow? Let us find out what happens to other plants that grow in the dark.

Find two carrots that have started to sprout. Plant each carrot in a can of damp soil. Put a glass jar over one carrot and a metal can over the other carrot. Look at the plants every day. What happens?

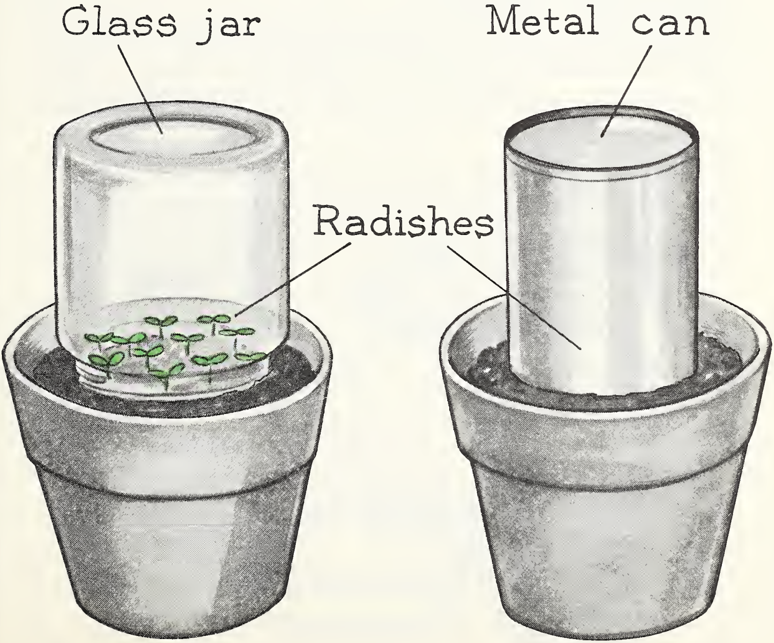
Most people would rather eat white celery than green celery, so gardeners cover the celery with soil and make it grow in the dark. Why?

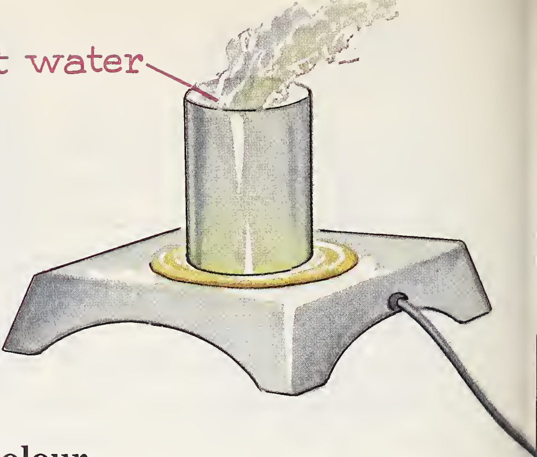


Plant some radish seeds in two pots. Let the radishes grow until they are about half an inch high. Then cover the radishes in one pot with a glass jar. Cover the other radish plants with a metal can. Keep both pots in a place that is light and cool. Give each pot the same amount of water.

Look at the plants every day. Always put the metal can back as soon as you are through looking. Keep the plants covered until you are sure of what happens when there is no light.

Try the same experiment with other kinds of plants. What is the colour of the plants that you have grown in the dark?





## Green Plant Colour

Have you noticed a green stain on your clothes after you played in the grass? These stains are made by the green colouring in the leaves and stems of the plants. If you rub a green leaf on white paper or cloth you can see the green colouring.

Boil some leaves in water until they are soft. Put the leaves in a glass dish and pour alcohol over them. After several minutes, pour the alcohol into a drinking glass or a small bottle.

Hold the alcohol up to the light and look at it. This is the green colouring that many plants make in the light. Plants cannot make this green colouring in the dark.

Alcohol and colour from leaf

Some kinds of house plants are partly green and partly white. Put one of these plants on a sunny window sill for several hours.

Pick one of the leaves and make a coloured drawing of it. Then boil the leaf and take out the green colouring with alcohol.

Lay the leaf in a dish and pour a little iodine on it. The iodine will show whether there is starch in the leaf.

Wash the leaf in cold water and hold it beside the drawing you have made. Where do you find starch in the leaf? Where is there no starch?

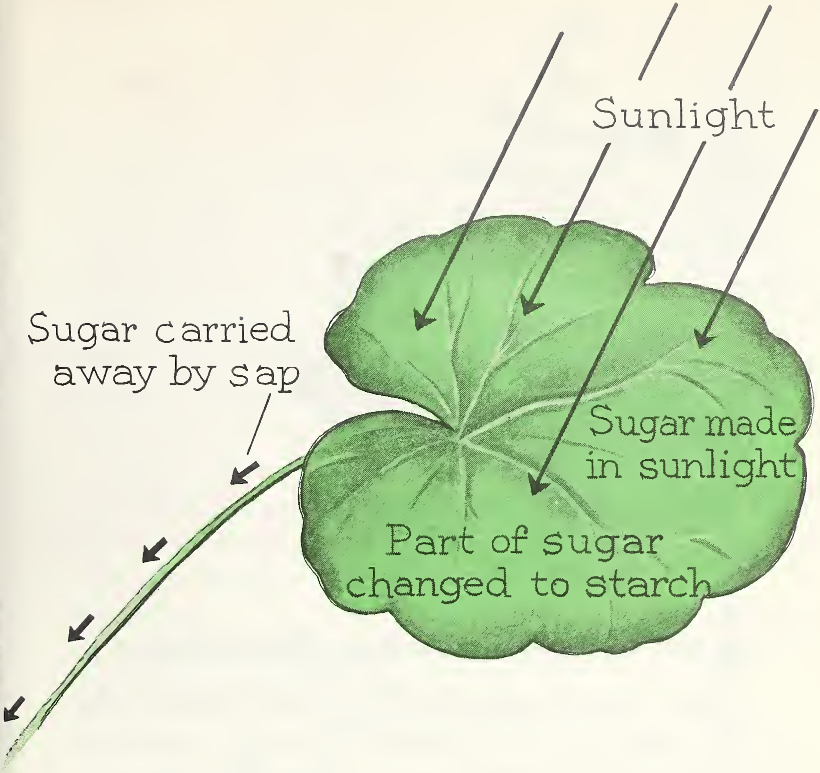
Try the same experiment with other plants that have leaves of two colours. Usually you will find starch in the parts of the leaves that were green. You will not find starch in the parts that were not green.

## Light and Food Making in Plants

Some bright morning put a green plant in a sunny window. Put another plant of the same kind in a dark place.

After several hours, cut a leaf from each plant. Take the green colouring from each leaf and test the leaves for starch. Which leaf has the more starch?

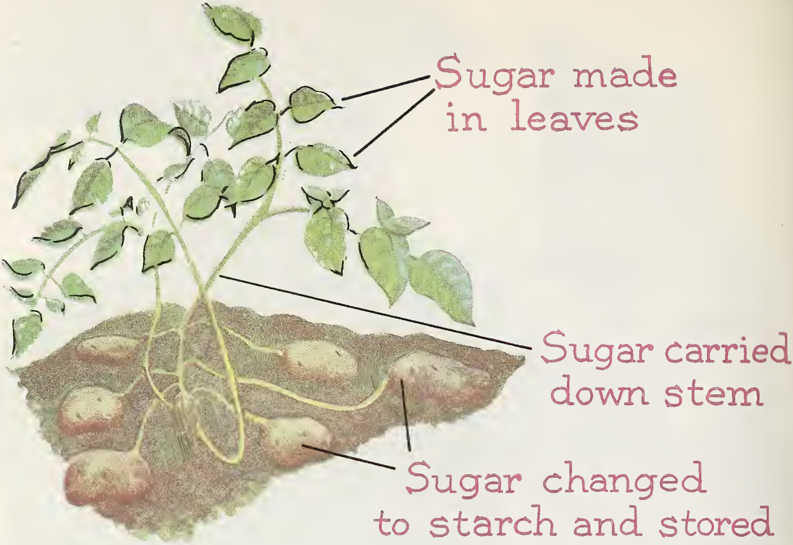
Try other kinds of plants. Do the plants in sunshine or the plants in darkness have more starch?



Scientists tell us that green plants can make sugar in the daytime. The plants must have the energy from sunlight for making sugar.

Sugar is made in the green parts of these plants. Then it is carried away in the sap of the plant. If sugar is made faster than it is carried away, some of it changes to starch and is stored in the leaf. At night, the starch changes to sugar and is carried away.

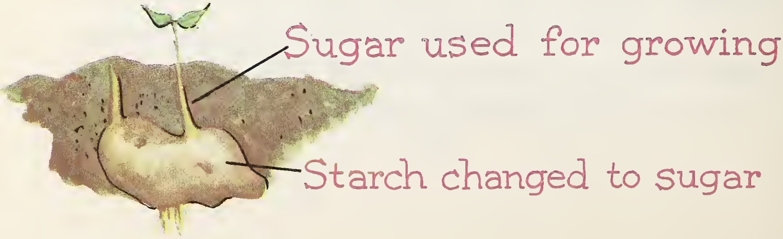
Can you tell why you found starch in the leaf of the plant that was on the window sill? Can you tell why you did not find starch in the other leaf?



## How Plants Use the Food They Make

Plants use the sugar they have made in several ways. They use part of it for making new leaves, roots, and other parts of the plants.

Some plants also store food for use during the next year. Potato plants change sugar to starch and store it in the potatoes. When spring comes again, the starch is changed back to sugar and is used by the growing plants.



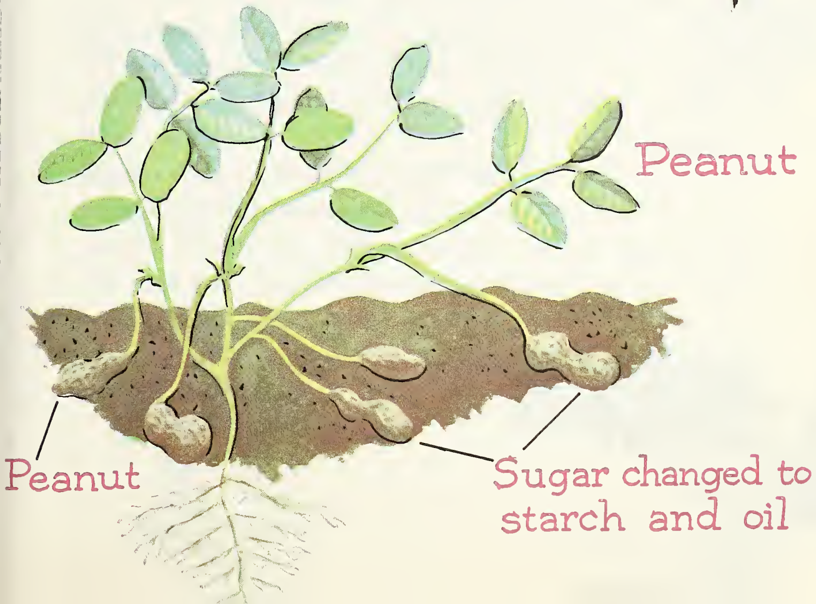
Sugar changed to starch and stored
Wheat

Plants also store food in their seeds. They change sugar to starch and oil. There is starch in corn and wheat. There is oil in peanuts and walnuts.

When spring comes, the seeds begin to grow. The little plants that are in the seeds use the stored food until they are able to make their own food.

Many animals eat the seeds of plants. Can you name some of these animals and the seeds that they eat? These animals are using the stored food in the seeds when they eat them.

People eat many seeds, too. What are some of the seeds you eat?

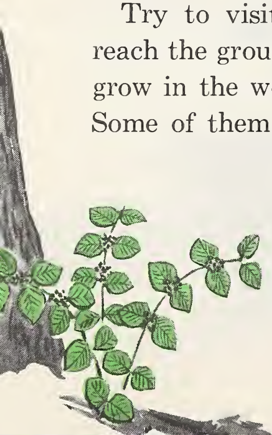

Peanut
Peanut
Sugar changed to starch and oil

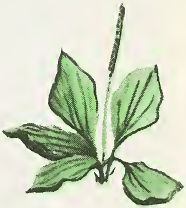
## Plants and the Light Supply

When you studied vines, you learned how they make good use of the supply of light. Many other plants also make good use of the light that falls on them.

Look up through a large tree. How much sky can you see? Look at the shadow of the tree during the middle of the day. How much sunlight passes between the leaves?

Try to visit a thick woods. Does much sunlight reach the ground? Study the leaves of the bushes that grow in the woods. Many of them have large leaves. Some of them hold their leaves so that they face the light. These plants make good use of the light that reaches them through the trees.

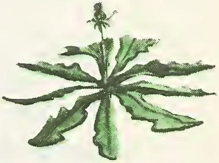




Plantain

Visit a field where there are many weeds. Try to find some of the weeds that are shown on this page.

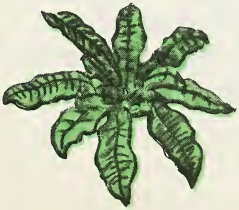
Notice how the leaves grow almost flat on the ground. Sunlight falls directly on them. Can you think of any other way that they might grow and get more light?



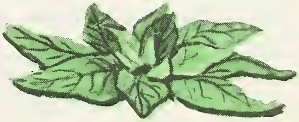
Dandelion

Do some of the leaves cover other leaves? Pick some of the leaves and try to place them so that each one gets more light.

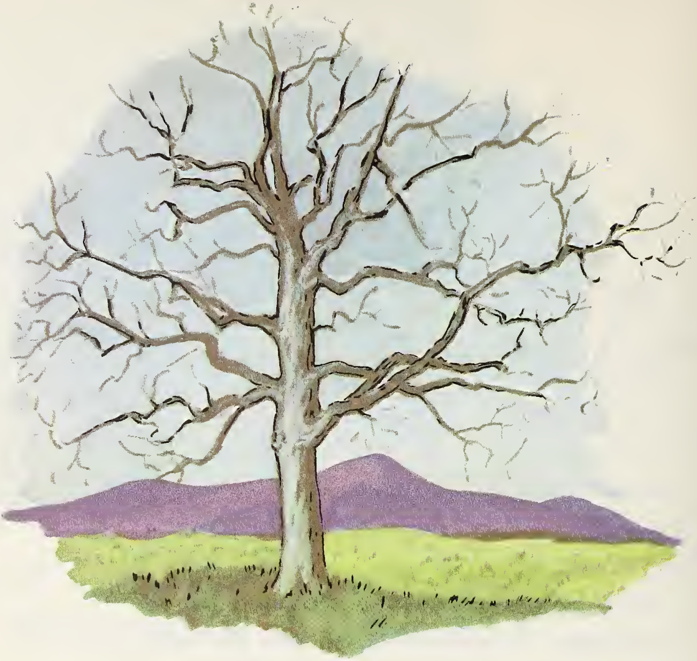
Visit a lawn where some of these weeds grow. Lift the leaves of the weeds and look at the grass underneath. What has happened? Why?



Teasel



Mullein

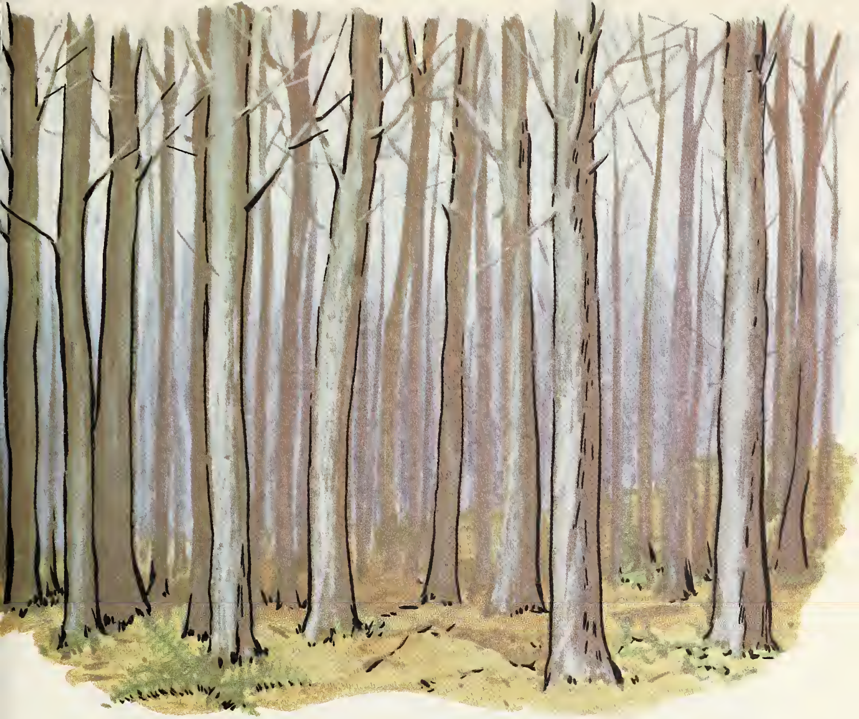


## Light and Tree Growth

A tree in an open field gets light from all sides. Leaves near the bottom of the tree get almost as much light as leaves at the top. Not many branches die because of lack of food.

The upper branches grow upward toward the light. The lower branches grow outward toward the light. The tree becomes large and spreading. It usually has many low branches unless someone cuts them off.

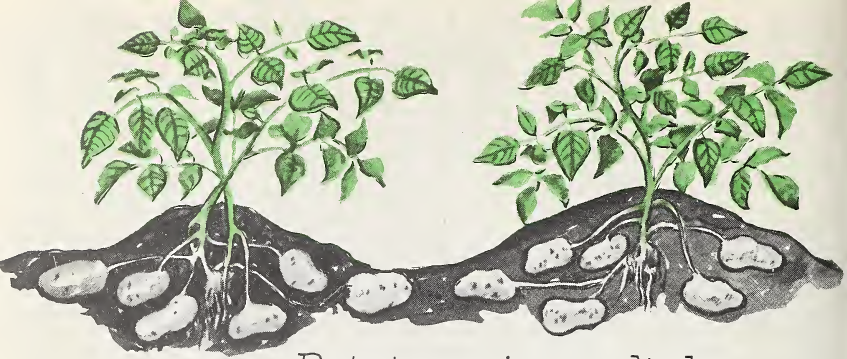
Study some of the trees in fields or yards near your school. Notice the way they grow. Make drawings or take pictures of some of them.



Trees in a thick woods get most of their light from above. Lower branches get little light and do not have enough food for good growth. Each year the lower branches have fewer leaves and grow less. At last they die and fall off. Only the top branches grow well.

Trees in a thick woods usually look like those at the top of this page. They are tall and their trunks are straight. The trunks do not have many branches except at the top.

Try to visit a thick woods and study the way the trees grow. If you cannot visit a woods, collect pictures that show how trees in a thick woods grow.



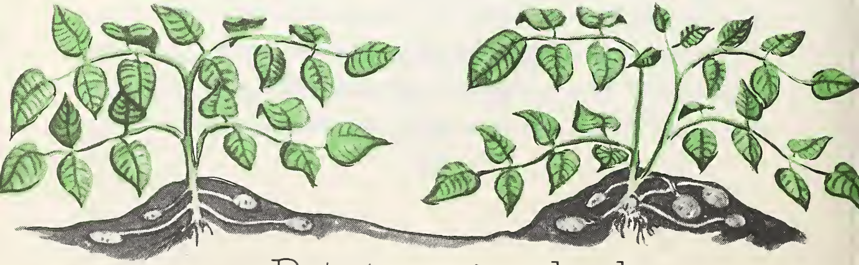
Potatoes in sunlight

## Light and Garden Plants

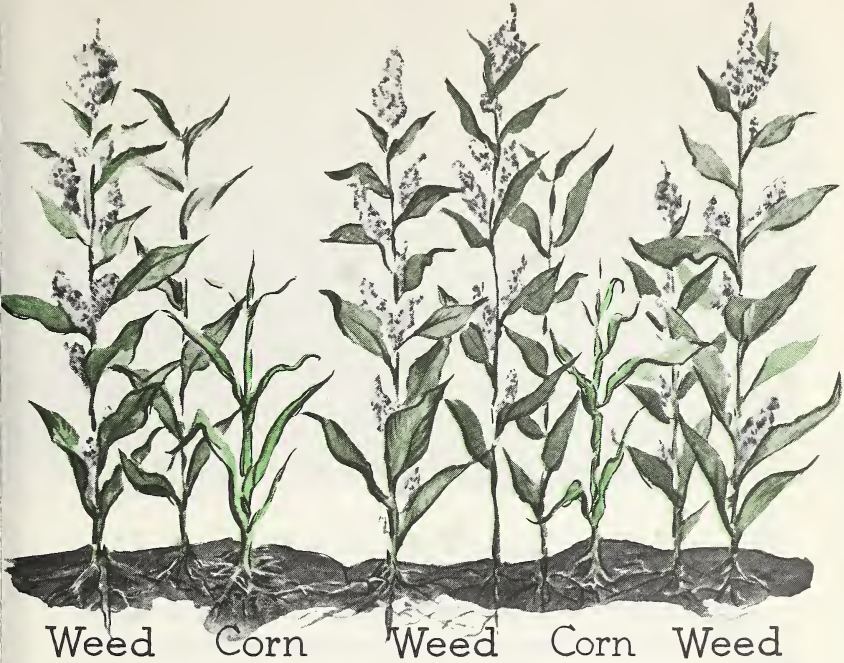
Most garden plants need plenty of sunlight. Gardens in the shade of trees or tall buildings do not usually do well.

At the top of this page are some potato plants growing in sunlight. Their leaves are making more food than the plants can use. The extra food is being stored in the potatoes.

At the bottom of the page are some potato plants growing in shade. The plants have grown bigger, but they are weak and unhealthy looking. The food that is made in the leaves is being used rapidly. There is little food left to be stored in the potatoes. These plants will not have large potatoes.



Potatoes in shade

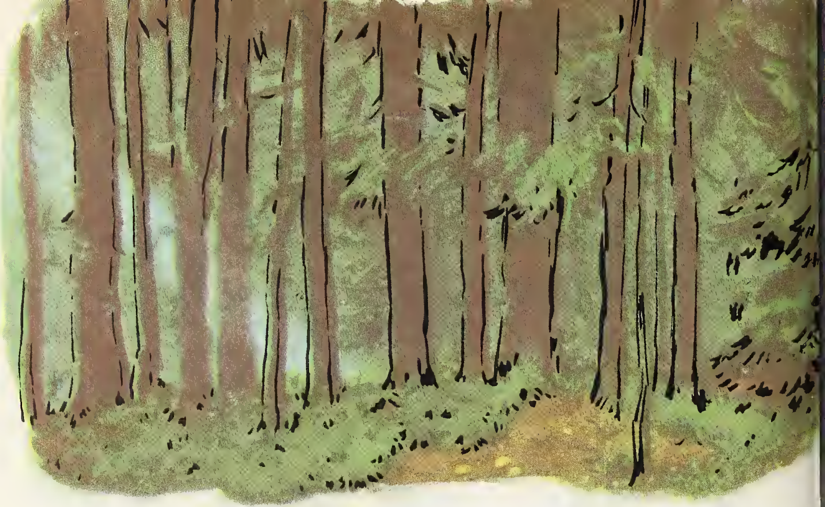


Weeds make trouble for people who have gardens. Weeds take water and minerals from the soil. They shade smaller garden plants.

Some kinds of weeds grow very rapidly. They quickly become taller than the garden plants. Then the garden plants do not get enough light to make their food. They become pale and unhealthy. They often die.

Weeds should be pulled from a garden while they are small. Then they will not harm the garden plants.

Bring in a tray of soil from a garden. Keep the soil moist and watch weeds grow from seeds in the soil. Notice how fast they grow.



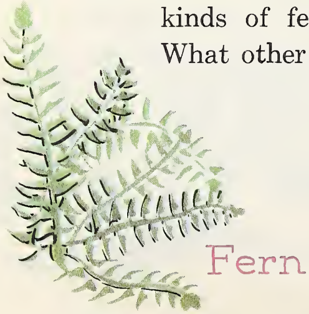
## Plants That Need Little Light

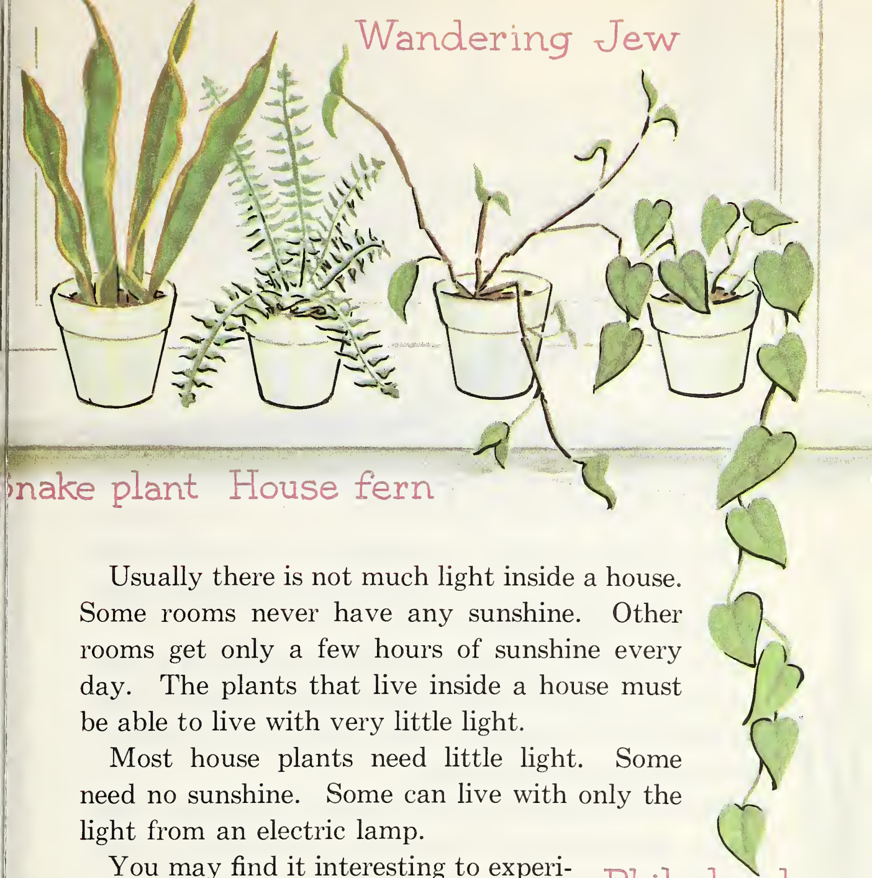
Some plants do not need much light to be healthy. You will find them growing in shaded places where other plants cannot live.

Look for these plants under bushes. Look between tall buildings. Look under low trees. Look in deep ditches.

You will find different plants growing in shaded lawns and sunny lawns. Collect the plants that grow in a sunny lawn. Collect the plants that grow in a shaded lawn. How many of them are different?

Try to visit a dark woods and look for the plants growing there. You may find several kinds of ferns and mosses in a dark woods. What other plants can you find there?

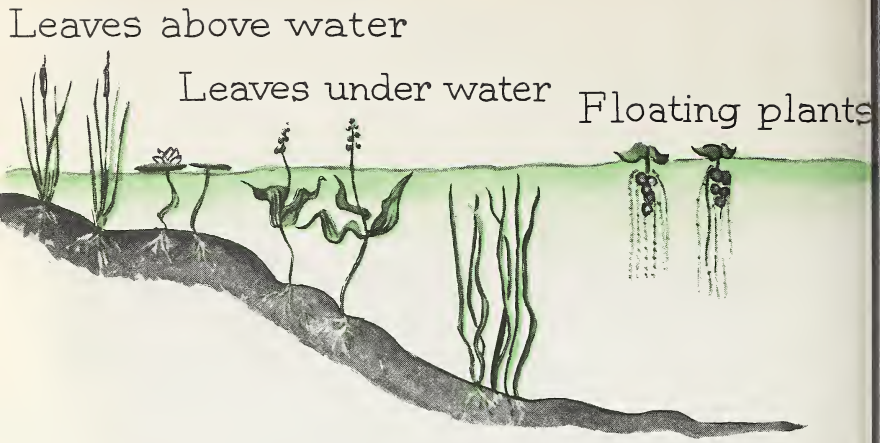




Usually there is not much light inside a house. Some rooms never have any sunshine. Other rooms get only a few hours of sunshine every day. The plants that live inside a house must be able to live with very little light.

Most house plants need little light. Some need no sunshine. Some can live with only the light from an electric lamp.

You may find it interesting to experiment with some of these plants to see how little light they need. Start several slips of one of them. Keep the slips in a box and give each slip a different amount of light each day. Keep one slip in the box all the time and never give it any light. Which slips stay green and grow? Which slips die?



## Water Plants and Light

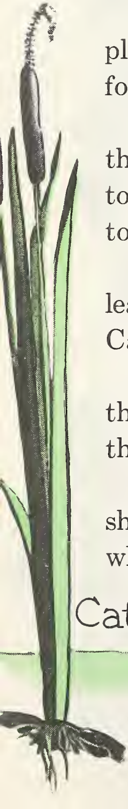
Green water plants need light just as other green plants do. They live only where there is enough light for them to make food.

Light does not go through water as well as it goes through air. Green water plants can live only near the top of lakes and oceans. They do not live at the bottom of deep lakes and oceans.

Some water plants live near the shore and send their leaves up into the air where there is plenty of light. Cattails are among the many plants that do this.

Some plants send up leaves that float on the top of the water. Water lilies are among the plants that do this.

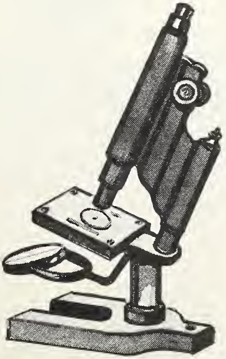
Some plants, like pondweed and eelgrass, live in shallow water and send their leaves up near the top where there is enough light for them to grow.

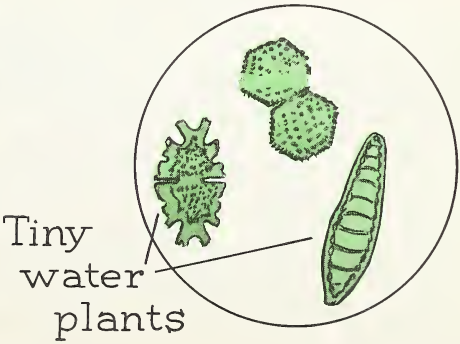


There are also many green water plants so small that you need a microscope to see them. They float near the top of the water or they live on larger plants and stones in shallow water. Sometimes there are so many of them that they make the water look green. These tiny plants are important because so many small water animals use them for food.

You will often find these tiny plants in bird baths, in small puddles of water, and in aquariums. They make a green coating on things in the water.

Raise some of these tiny plants in your classroom. Scrape some of the green "scum" from a pool or puddle where it grows. Put the scum in jars of water taken from the same place. Put one jar in sunshine. Keep the other jar in a shaded place. Which grows better?





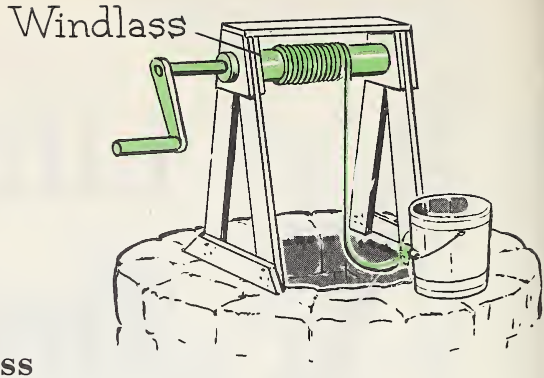
## Plants That Are Not Green

There are many plants that are never green. These plants cannot make their own food.

Some of these plants take their food from living plants. Others take their food from dead plants. Those that take their food from dead plants help change the dead plants into soil.

1. Why do green plants need light?
2. What happens if a green plant is kept in darkness?
3. How do green plants use the food they make?
4. Why are there no green plants living in the bottom of a deep lake?
5. Why do trees living in a woods look different than trees growing in a field?
6. Where do plants that are never green get their food?
7. Why are green plants important to people and to animals?

# Lifting Things

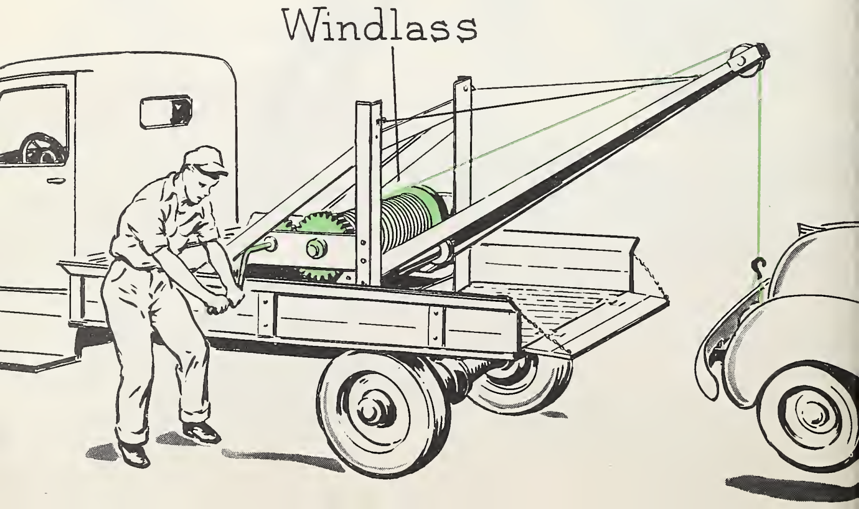


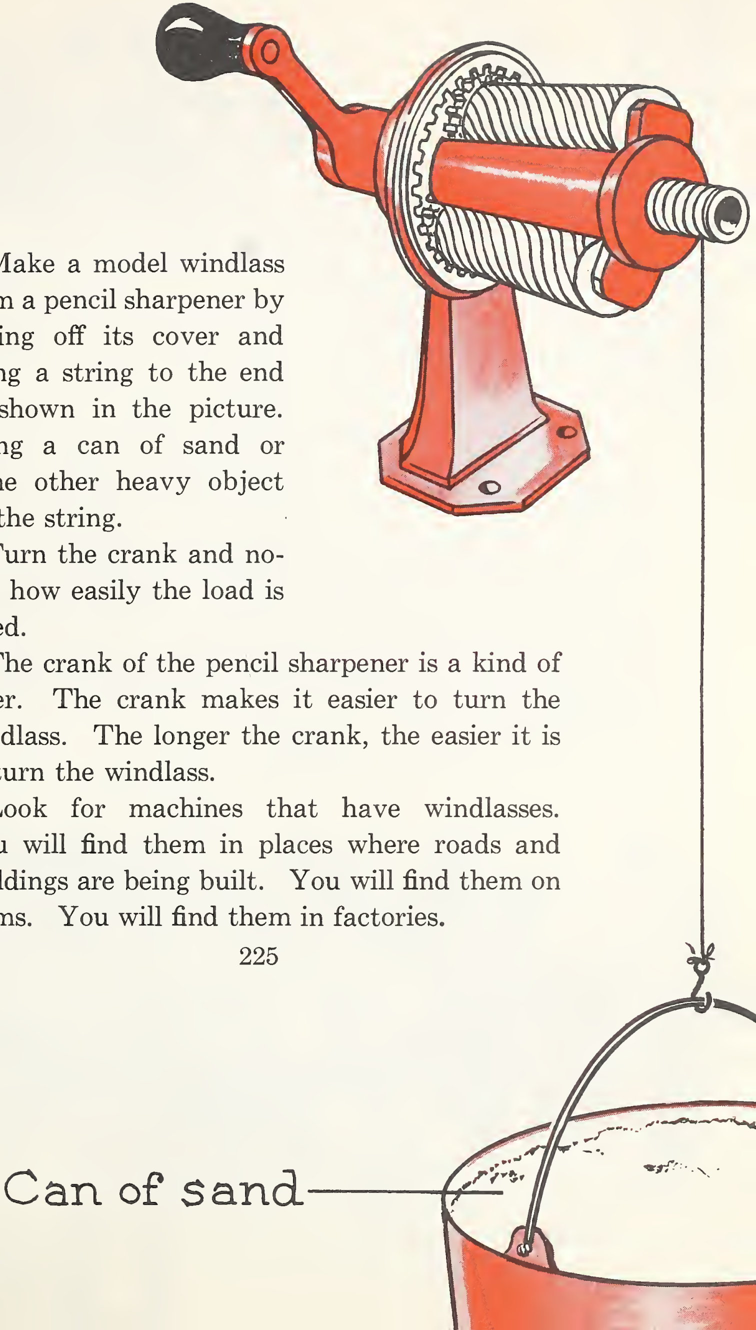
## The Windlass

Many things must be lifted from one place to another. We must take coal from mines, carry people to the tops of tall buildings, and load ships. Make a list of some of the things that we lift from one place to a higher place.

People have invented many machines to lift things. Many of these machines have windlasses. A windlass is used to wind up a rope or a cable.

Windlasses have been used for hundreds of years. The early ones were made something like the windlass shown in the upper picture.



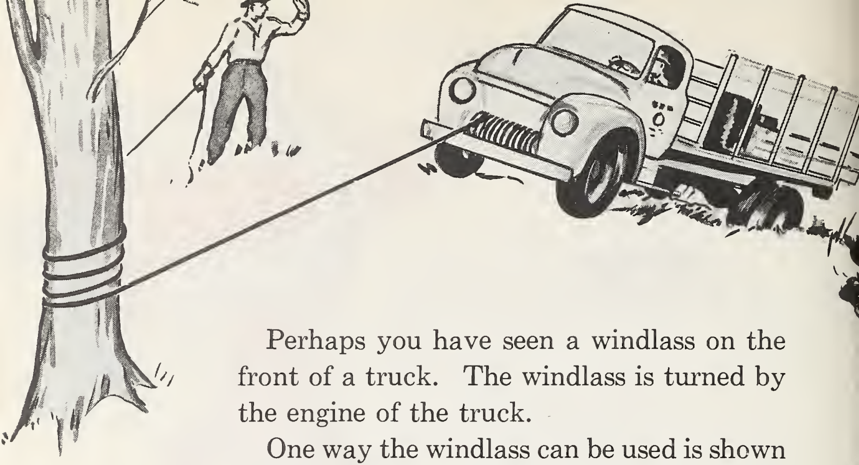


Make a model windlass from a pencil sharpener by taking off its cover and tying a string to the end as shown in the picture. Hang a can of sand or some other heavy object on the string.

Turn the crank and notice how easily the load is lifted.

The crank of the pencil sharpener is a kind of lever. The crank makes it easier to turn the windlass. The longer the crank, the easier it is to turn the windlass.

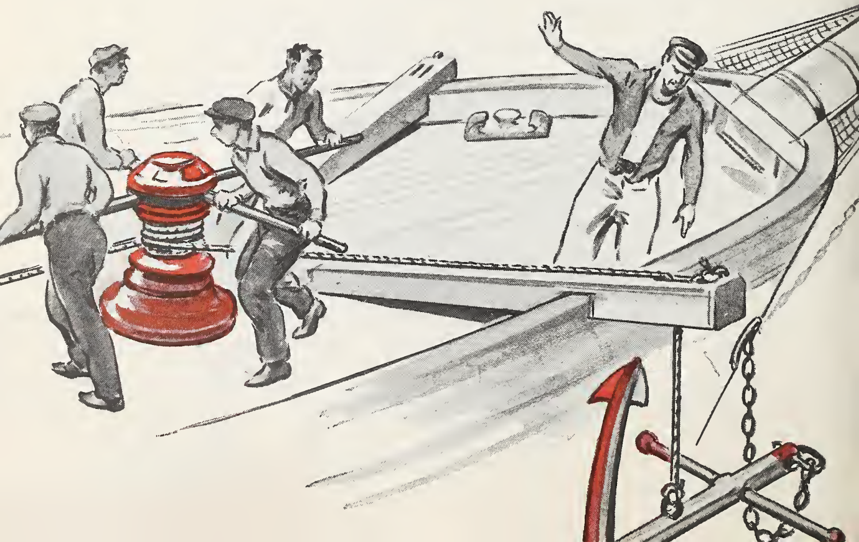
Look for machines that have windlasses. You will find them in places where roads and buildings are being built. You will find them on farms. You will find them in factories.

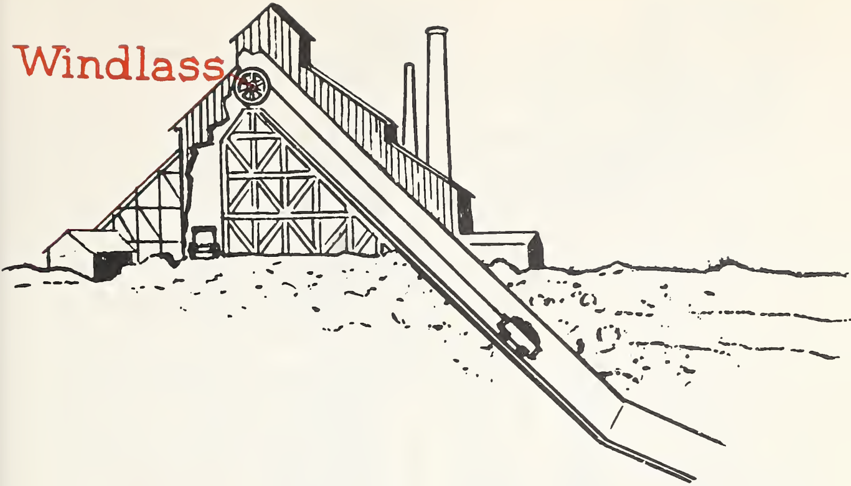


Perhaps you have seen a windlass on the front of a truck. The windlass is turned by the engine of the truck.

One way the windlass can be used is shown in the picture. The truck is in mud and its wheels cannot move it ahead. The workers have wound a cable on the windlass and fastened it to a tree. The windlass is pulling the truck from the mud.

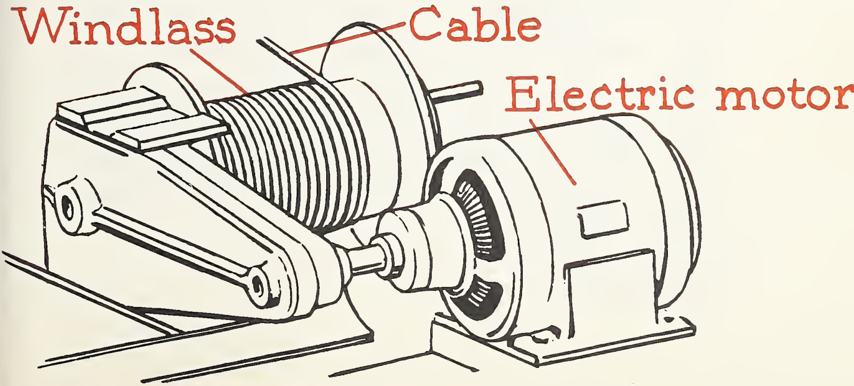
Windlasses are also used on ships. They are used to raise the anchors and take the cargo from the ships. In the days of large sailing ships, windlasses were used to raise the big sails.

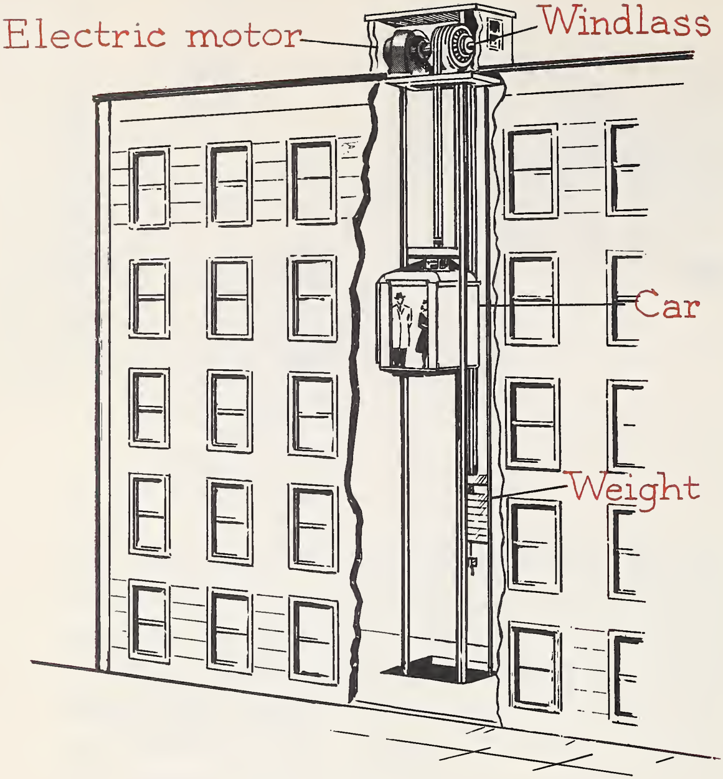




A windlass is sometimes used to pull cars of ore and coal from mines. In the picture we see how cars of coal are pulled up a steep tunnel. When the cars reach the top, they are emptied and sent back for new loads.

Windlasses were once turned by hand. Today most of them are turned by motors. Some windlasses are turned by gasoline motors, some by electric motors, and some by steam engines.





## Elevators

People are usually lifted to the tops of tall buildings. If they had to climb hundreds of stairs, they would waste a great deal of time and become very tired.

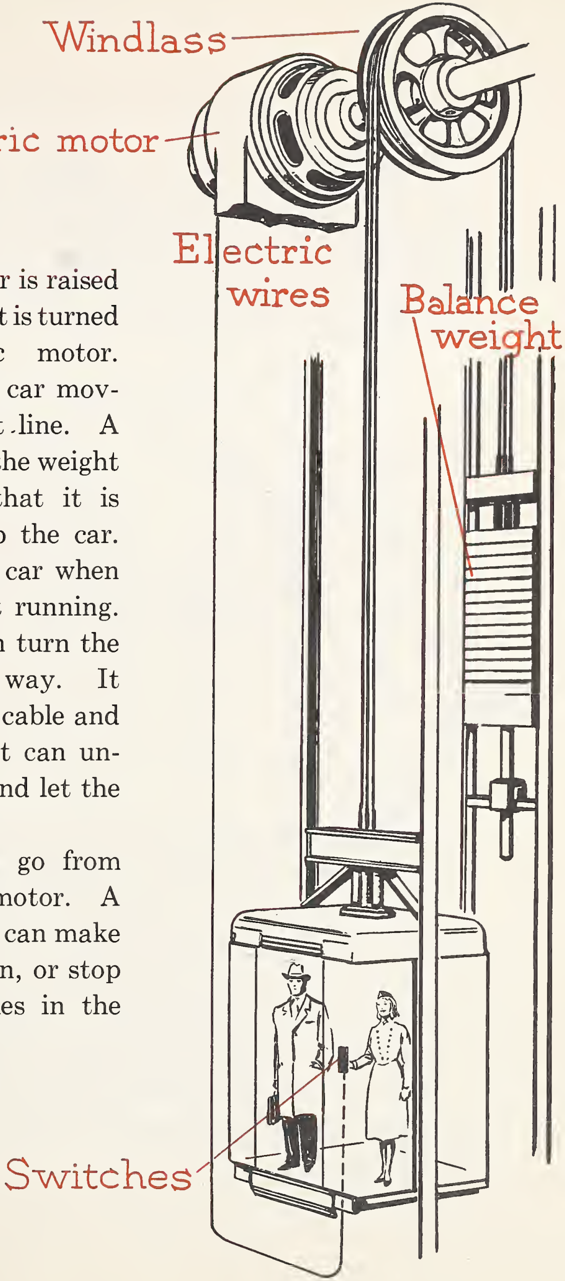
There are elevators for freight as well as for people. Factories and large stores often have freight elevators.

What kinds of buildings have elevators for people? Do you know of some buildings that have freight elevators?

An elevator car is raised by a windlass that is turned by an electric motor. Tracks keep the car moving in a straight line. A weight balances the weight of the car so that it is easier to pull up the car. Brakes hold the car when the motor is not running.

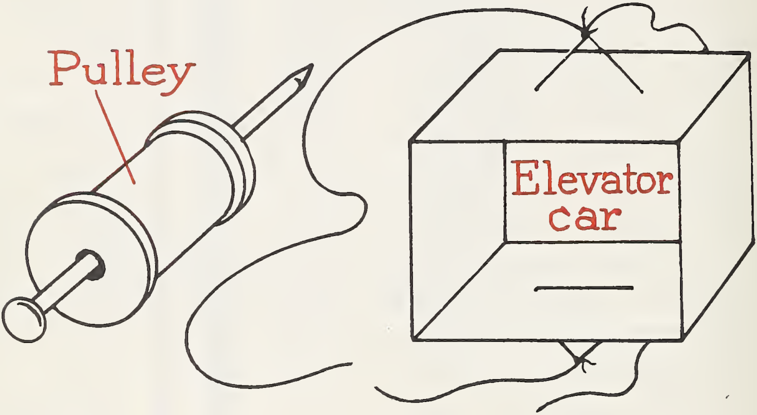
The motor can turn the windlass either way. It can wind up the cable and raise the car. It can unwind the cable and let the car down.

Electric wires go from the car to the motor. A person in the car can make it go up, go down, or stop by using switches in the car.



## A Model Elevator

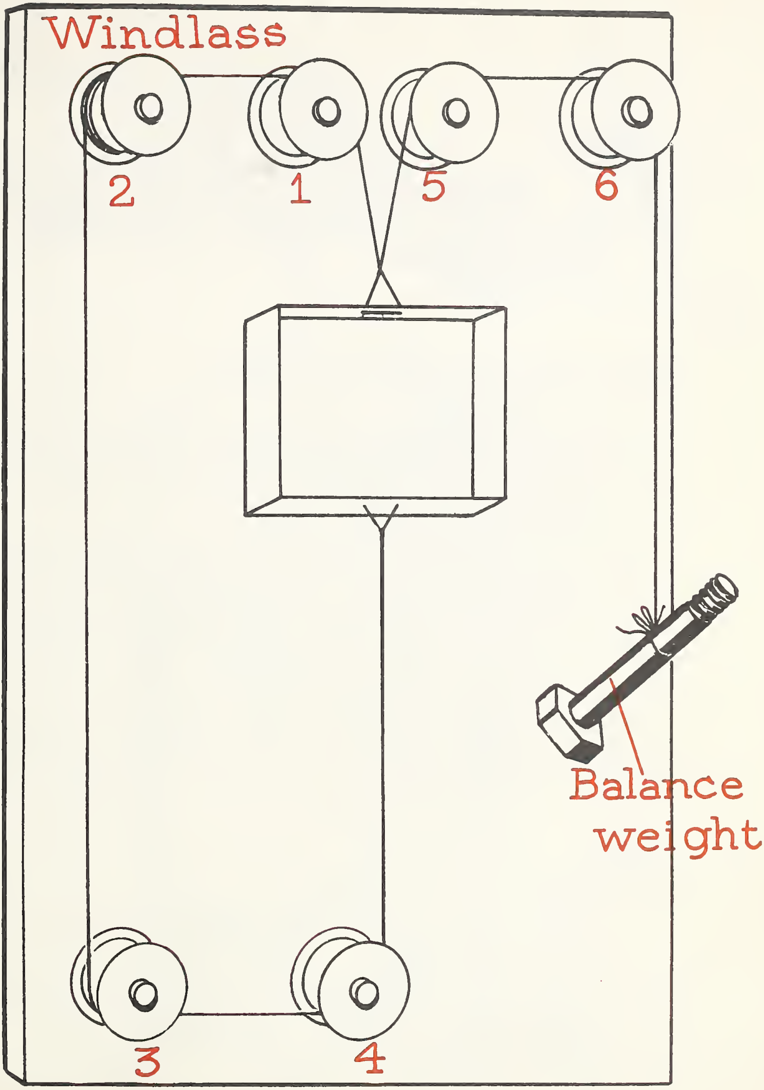
These pages show how to make a model of an elevator. A small cardboard box is used for the elevator car. To keep the car from swinging, tie a string to the bottom as well as to the top of the car. This is easier than making a track for the car.

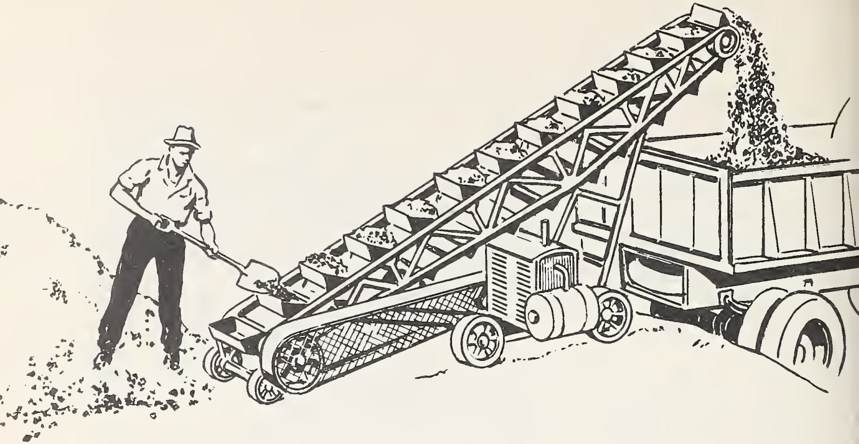


Drive nails through spools into a board as shown on the next page. Slip the string of the car over the spools marked 1, 2, 3, and 4. Wind the string several times around spool 2. This spool will be the windlass.

Tie a second string to the top of the car and run it over the spools marked 5 and 6. Fasten a small weight to this string to balance the weight of the car.

Turn the windlass with your fingers. The car will go up and down. Perhaps you can make a model building to put it in.


Windlass
Balance weight

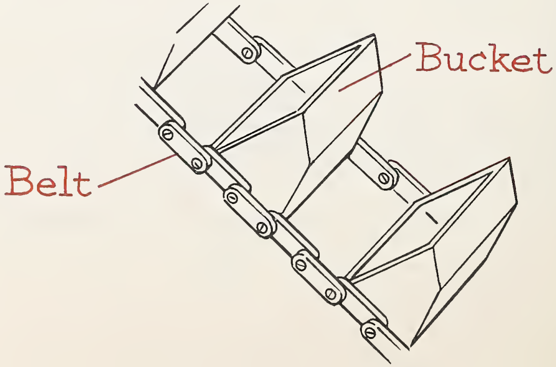


## Other Kinds of Elevators

Machines like this are sometimes used to load trucks with soil, grain, coal, and other loose things. The picture shows how one works.

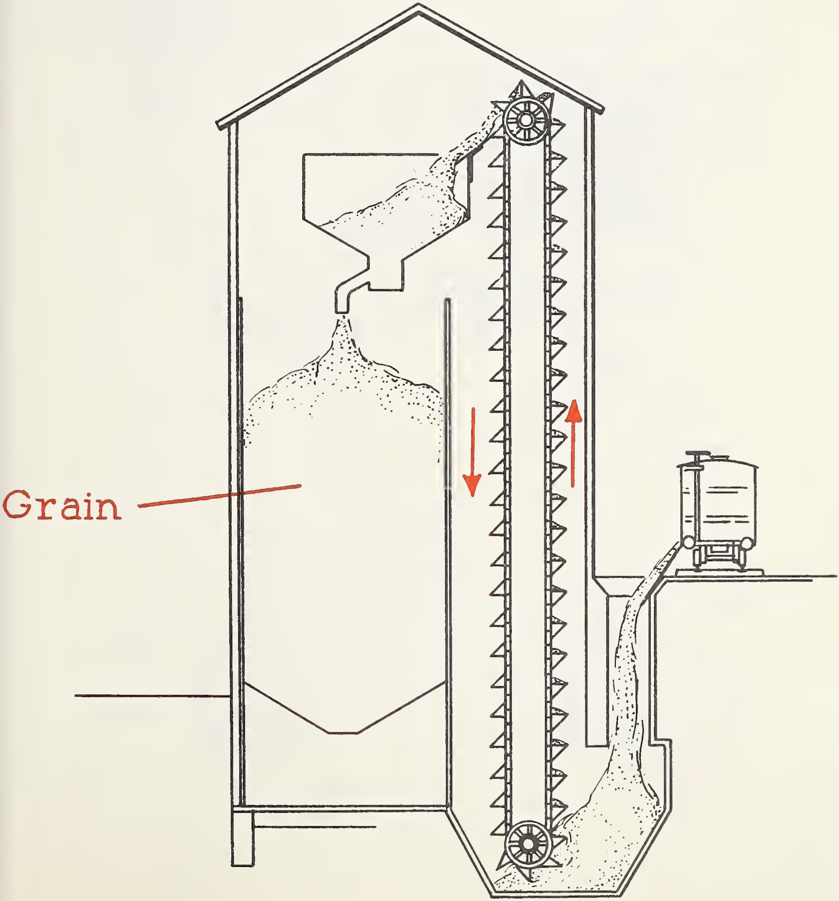
Small buckets are fastened to a belt. The belt is driven around by a motor. As the belt goes around, each bucket picks up a small load and carries it upward. When the bucket gets to the top, it drops its load. Can you see why it drops its load?

These machines are often called "loaders." Have you seen one being used? What was it being used for?



Buckets on belts are used in buildings that store such things as grain, coal, and sand. The buildings are often called "elevators." This is a grain elevator.

The grain comes in trucks or in railroad cars and is dumped at the bottom of the elevator. The buckets carry the grain upward and dump it in bins.

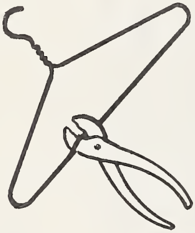


## Pulleys for Lifting

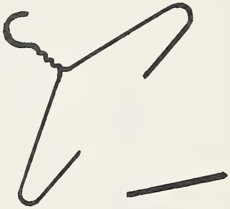
Pulleys are often used for lifting things. You have probably seen a pulley at the top of a flagpole. Where else have you seen a pulley in use?

You can buy small pulleys to experiment with in hardware stores. You can also make pulleys from spools and wire coat hangers.

Cut out the centre of the clothes hanger and push the ends of the wire through the spool. Bend the ends of the wire down to hold the spool, but be sure that the spool turns easily. You can now put a string over the spool, tie a load to it, and raise the load by pulling on the other end of the string.



1



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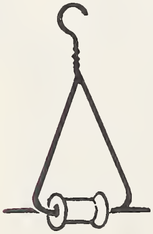

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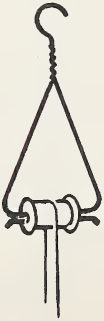

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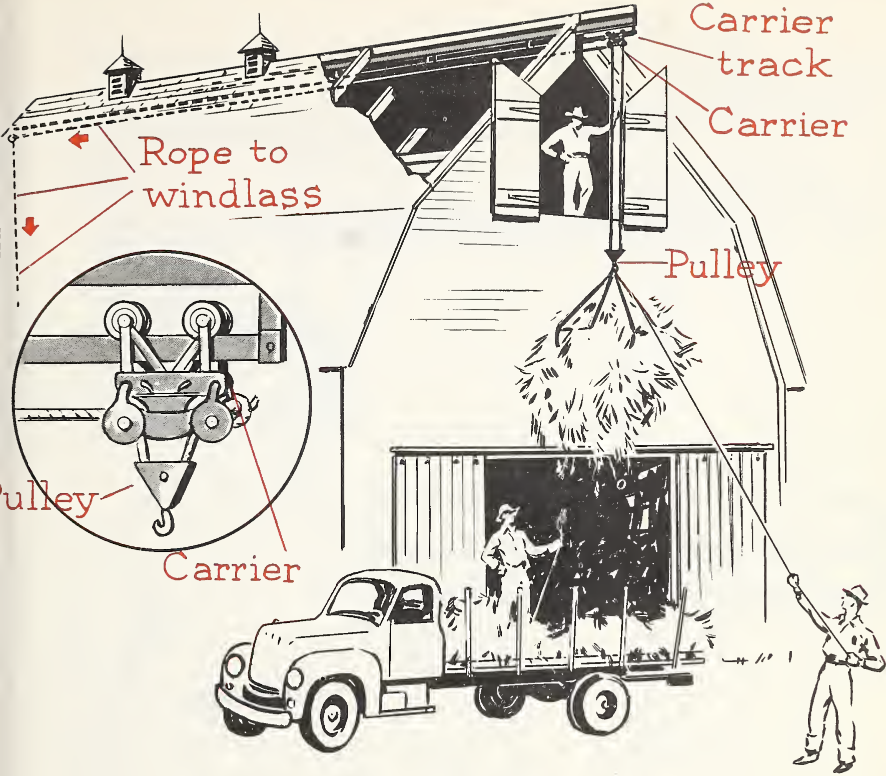


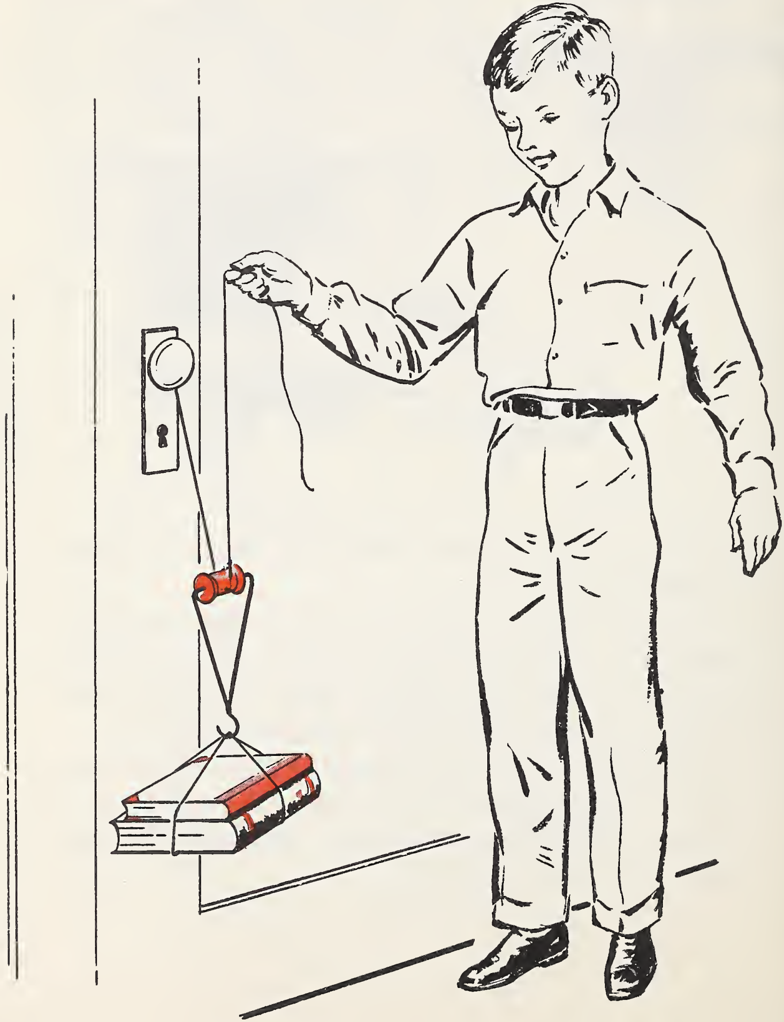
This picture shows one of the many ways that pulleys are used on the farm.

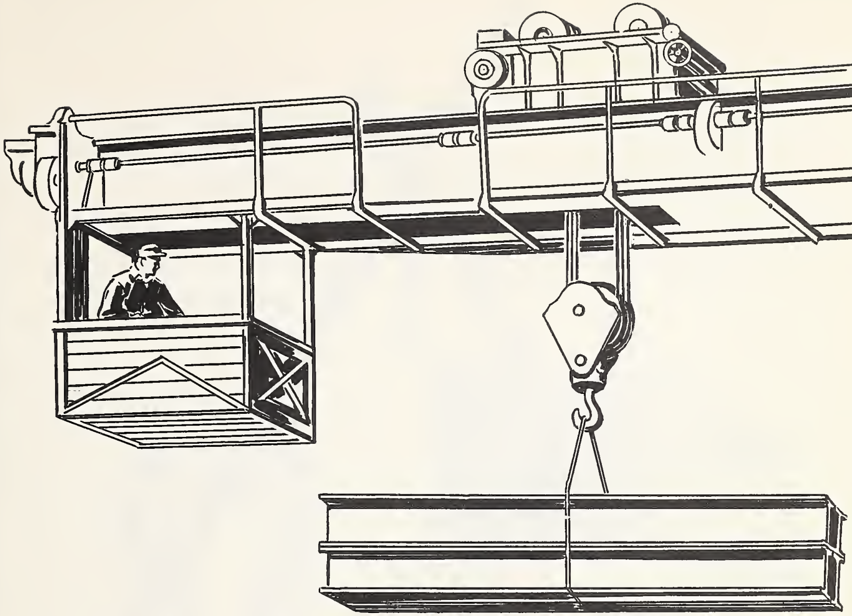
A large hayfork is fastened to a rope that runs over a pulley to a windlass inside the barn. The hayfork is dropped into the load of hay. Then the windlass pulls on the rope and raises the fork with its load of hay.

The pulley is fastened to a carrier that hangs from a track. When the hayfork has been raised as far as it will go, the carrier runs along the track into the barn. There the hay is dropped.

You can use pulleys in a way that will make it easier for you to lift a load.

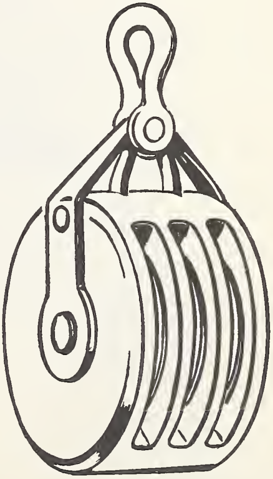
Tie one end of a string to something like a doorknob. Put a pulley on the string and tie a heavy load to the pulley. Then pull up on the string. Is it easier to lift the load with the pulley or without it?



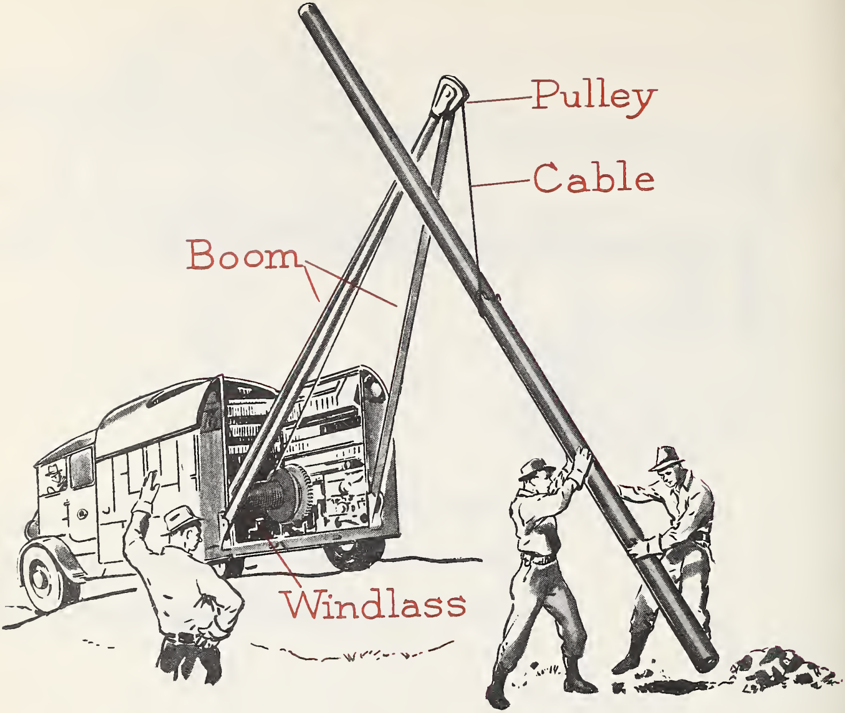


Very heavy things can be lifted easily if many pulleys are used as shown in the picture. Here a heavy load of steel is being lifted and moved in a factory. How many pulleys are working together to lift this load?

You will see two or more pulleys working together in many places. Look for them and tell the class about them.



A double pulley



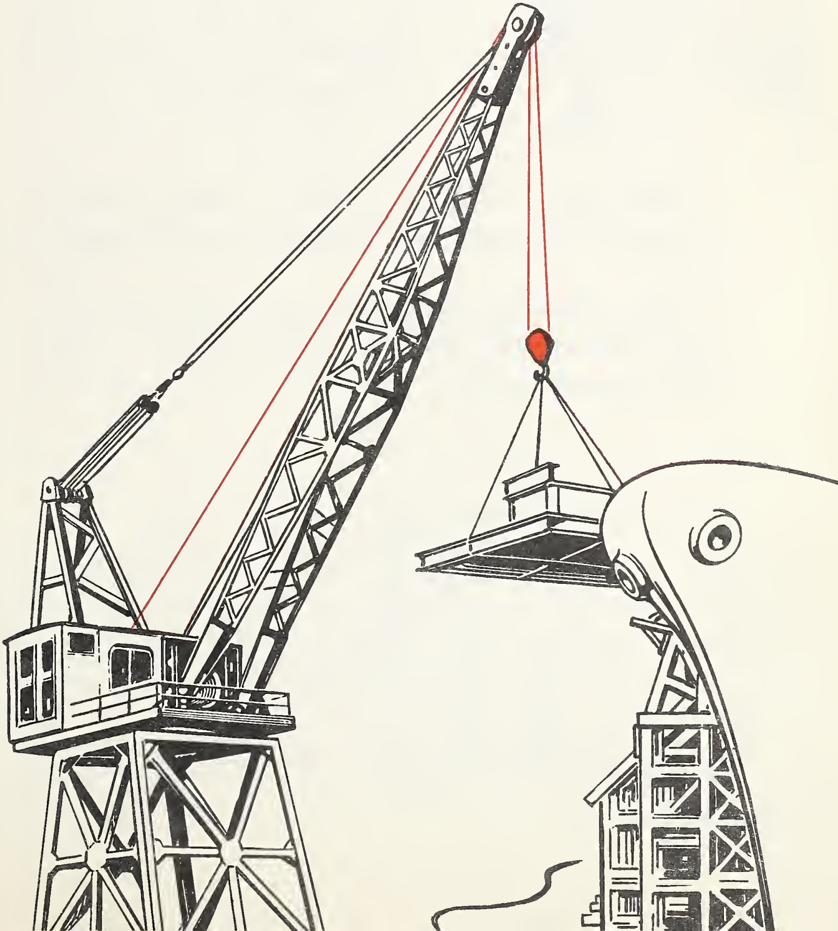
## Derricks

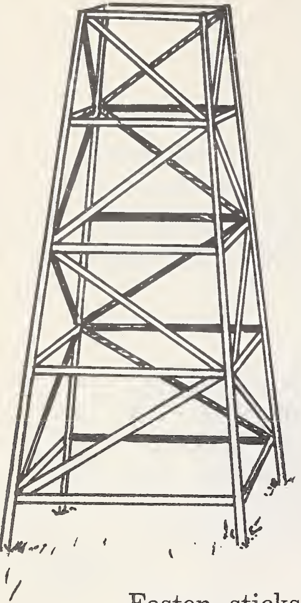
These telephone linemen are lifting a heavy pole. They are using a derrick that is on their truck. Study the picture and tell how the derrick lifts the pole. Have you ever seen a pole lifted this way?

The men fasten a steel cable to the pole. The cable runs over a pulley at the end of the boom. The cable is wound up by a windlass. A motor turns the windlass.

When everything is ready, the men start the motor. The windlass winds up the cable and the pole is lifted. One end of the pole is then set in the hole that has been dug for it.

Derricks do the heavy work of the world. We use them to build ships like the one below. We use them to build bridges and tall buildings. We use them to load ships and railroad cars. We use them to lift heavy machinery and big logs. Where have you seen derricks being used?





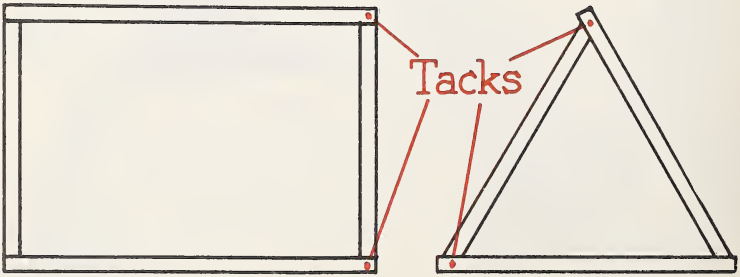
## Triangles for Support

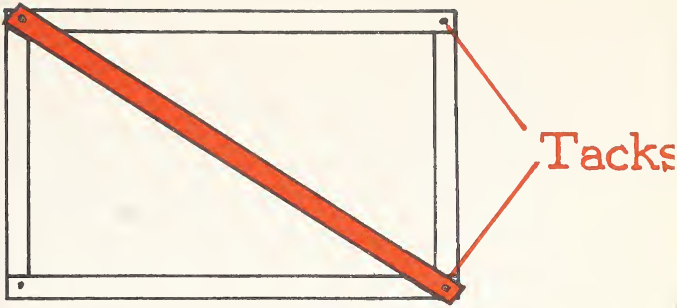
Towers and derricks are usually made of many triangles. Strips of metal are fastened together at the ends so that triangles are formed.

Have you ever wondered why triangles are used this way? What do you think would happen if squares and rectangles were used?

Fasten sticks together to make a triangle and a rectangle. Use tacks to hold the ends of the sticks together.

Push sidewards against the top of the rectangle. Then push against the top of the triangle. Which holds its shape better?

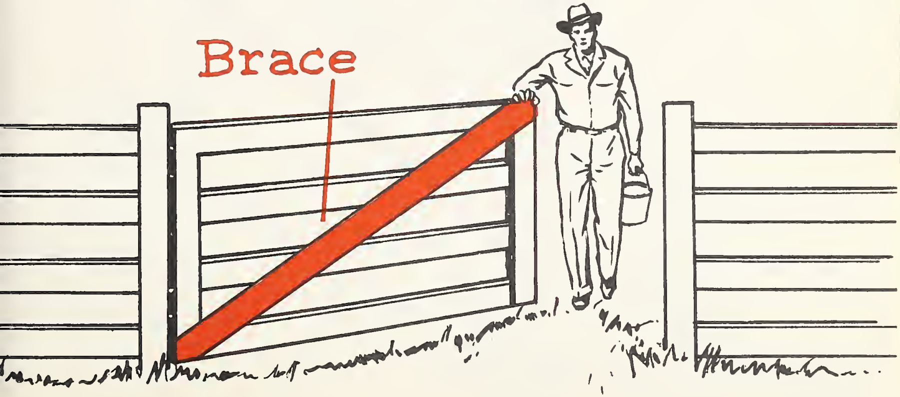


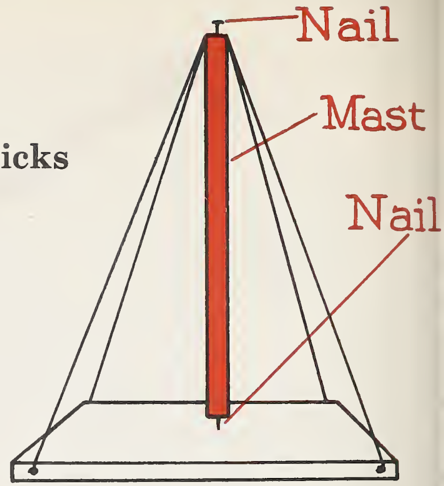


Fasten a long stick across the rectangle that you have been experimenting with. Does the rectangle hold its shape better now? Notice that you have changed the rectangle into two triangles.

Perhaps you have seen a gate made like the one below. It is a rectangle made of boards. One longer board is nailed from corner to corner. This board is called a brace. The brace makes the gate into two triangles.

Look for other places where triangles are used to brace things and keep them from folding. Bring in pictures that show triangles being used this way.





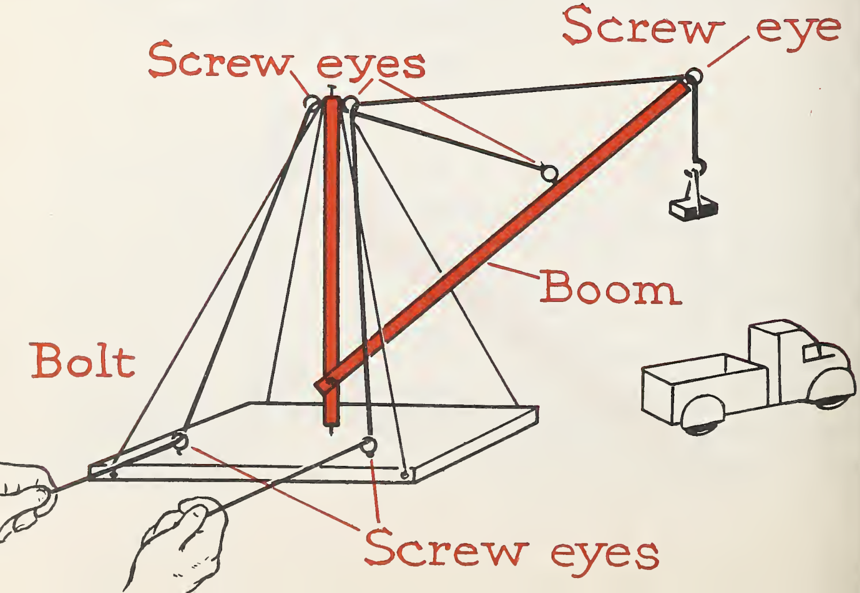
## Making Model Derricks

Use a two-foot stick for the mast of this derrick. Use a longer stick for the boom.

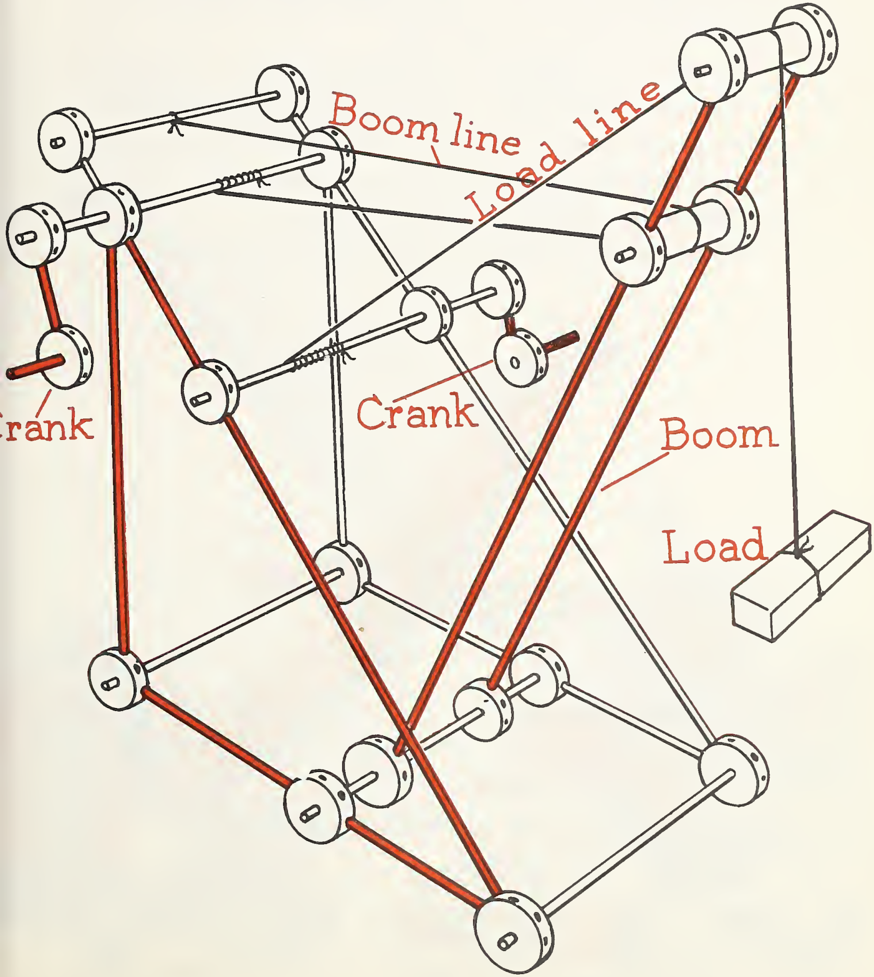
Fasten the boom to the mast with a small bolt. Drive a headless nail into the lower end of the mast.

Make a nail hole in the centre of a board. Stand the mast in this hole. Hold the mast up straight with strings as shown above.

Use strings for cables and screw eyes for pulleys. The picture shows where to put them. Pull on the strings to raise the load and the boom.



If you have a model-building set, you can make different kinds of derricks. Here is a simple one to build. It has two windlasses, one to raise the load and one to raise the boom. It is much like a big derrick except that the windlasses are turned by hand.



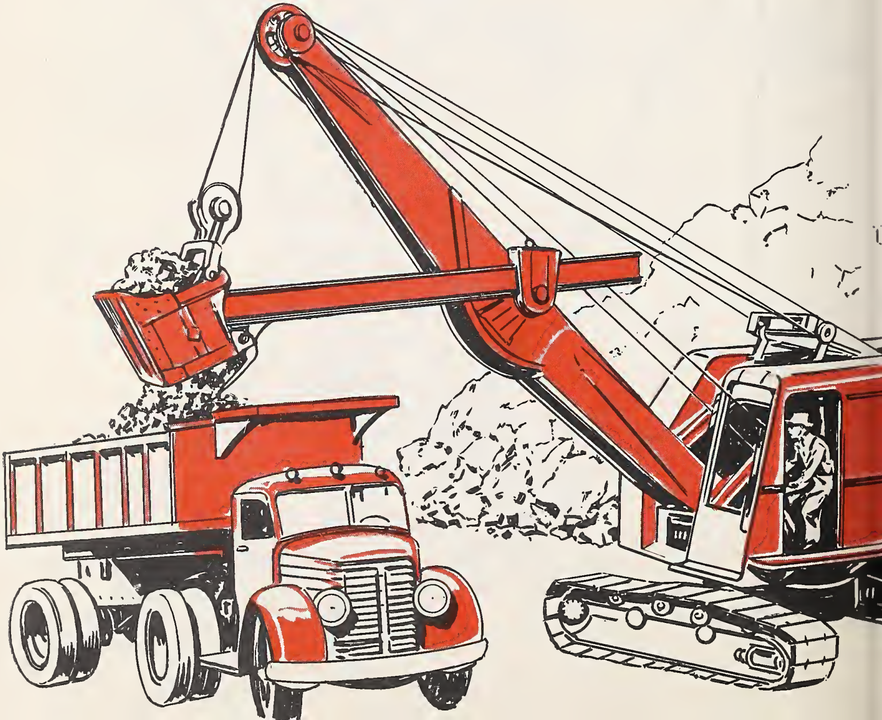
## Moving Soil

A hundred years ago, nearly all digging was done with hand shovels and pickaxes. Today we have many kinds of machines to do our digging for us.

One common digging machine is the power shovel. The power shovel has a scoop called the "dipper" that picks up the soil or loose rock.

The dipper is raised by a cable running over a pulley at the end of the boom. As the dipper moves upward, it scrapes up a load of soil. The whole shovel is then turned until the dipper is over a truck or car. Then the dipper is opened and the soil falls out.

Where have you seen power shovels being used?

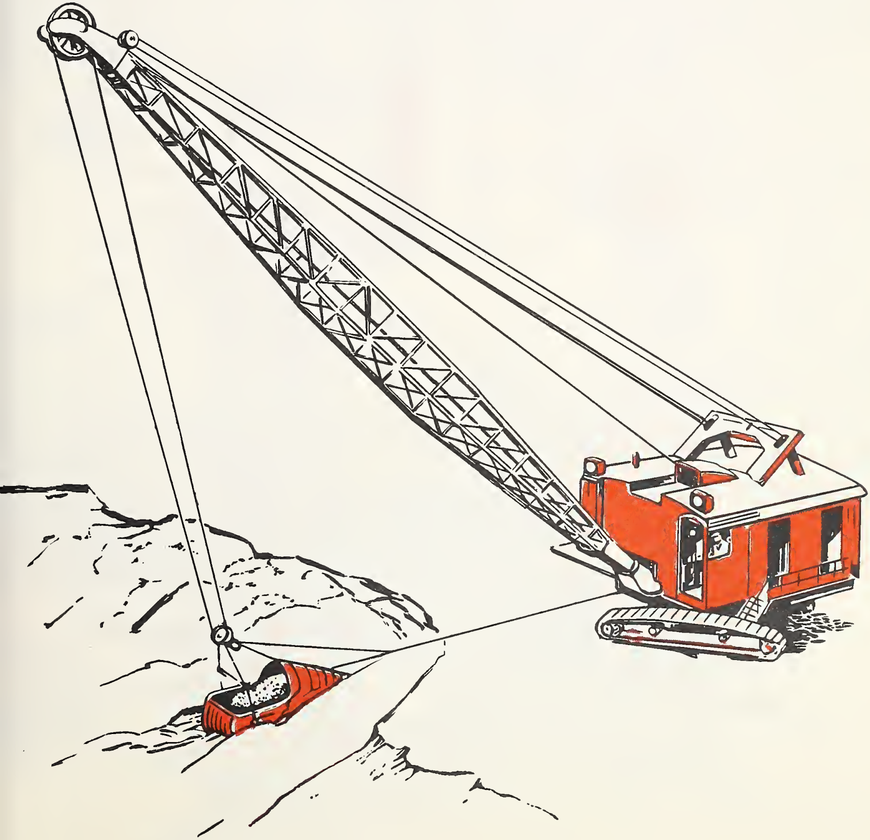


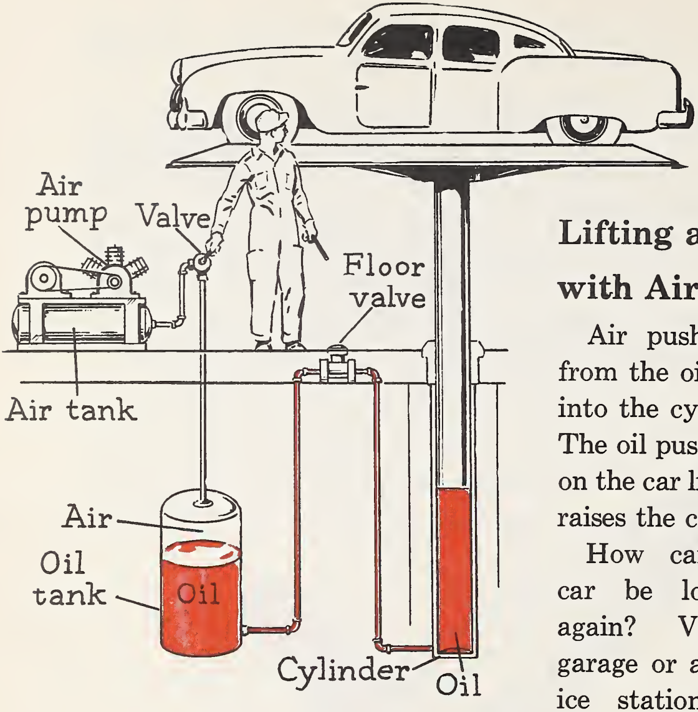
There are several other kinds of diggers. The one shown on this page is used to dig below the level of the ground. Can you tell how it works?

There are other diggers that make ditches and trenches for pipes. Have you seen one of them? If so, tell how it works.

Find out about other kinds of diggers. Read about the machines called "dredges" that are used to dig under water to deepen rivers and harbours.

Make models of some of these different diggers.





## Lifting a Car with Air

Air pushes oil from the oil tank into the cylinder. The oil pushes up on the car lift and raises the car.

How can the car be lowered again? Visit a garage or a service station and find out.

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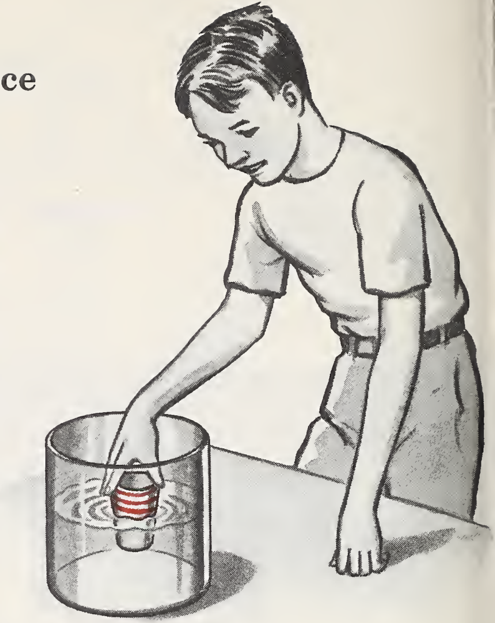
1. What does a windlass do?
2. How may trucks be loaded with loose things such as sand?
3. How is an elevator car raised?
4. How may several pulleys be used to raise a heavy load?
5. What are derricks used for?
6. Tell about some of the machines that are used for digging.
7. Where are pulleys used?

# Boats

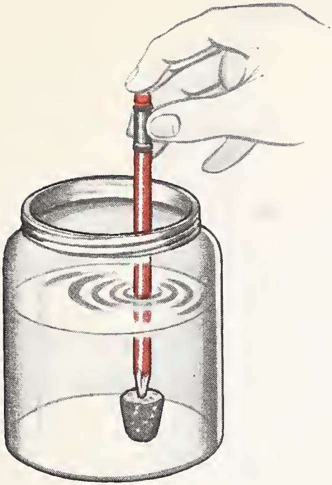
## The Upward Force of Water

Set a paper cup in a jar of water. Press down on it with your hand.

Notice how the water pushes up on the cup as you press down on it.



Fill a balloon with air. Try to push the balloon under water. Notice how the water pushes up against the balloon.

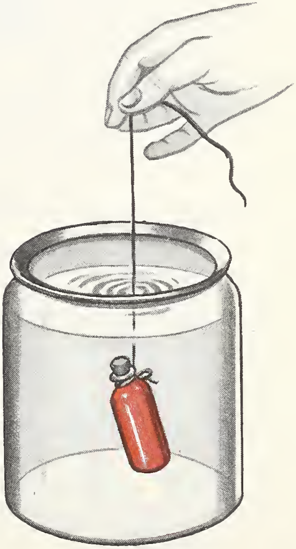


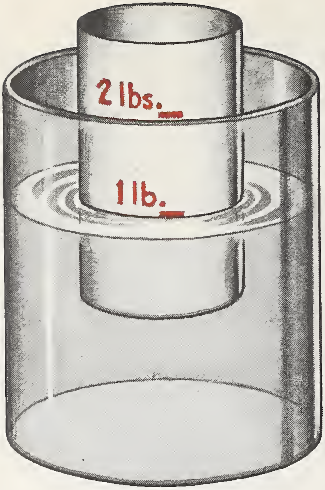
Push the point of a pencil into a large cork. Push the cork under water.

Does the water push up on the cork?

Fill a small bottle with water and put a cork in it. Tie a string to the bottle and lower it into a jar of water.

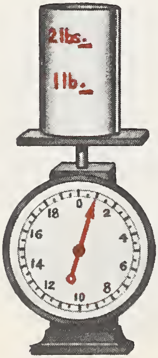
Does the bottle seem to weigh as much in water as in air? Does the the water seem to push up on the bottle?



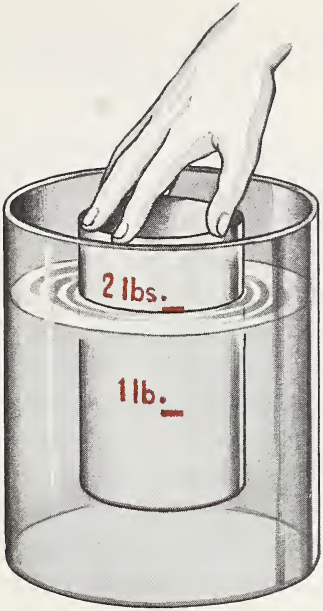


Float a can in water. Weigh out one pound of sand and put it in the can. Mark the water line on the can. Put in another pound of sand and mark the new water line. Add more sand one pound at a time until the can is about to sink.

You can now use the can to weigh things. Put in enough stones to sink the can to the two-pound line. The stones should weigh about two pounds. Weigh them and see.

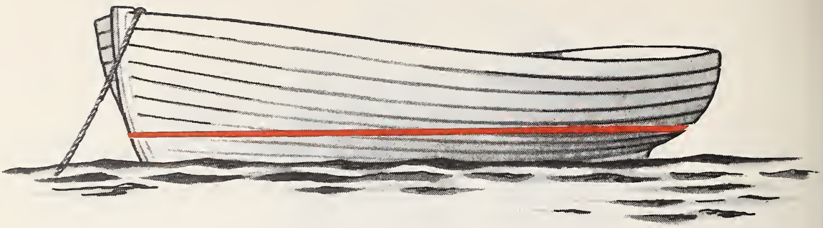


Weigh out nails and other things the same way.



Put the can you have just marked in water. Press down on the can until the water level is at the two-pound line. You are pushing down with a force of two pounds. The water pushes up with a force that just balances your push. The water must be pushing up with a force of two pounds.

The more of the can there is under water, the greater is the upward force of the water.



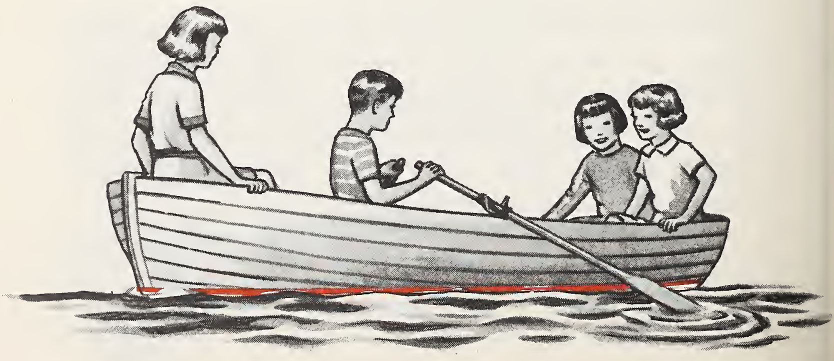
## Loaded and Unloaded Boats

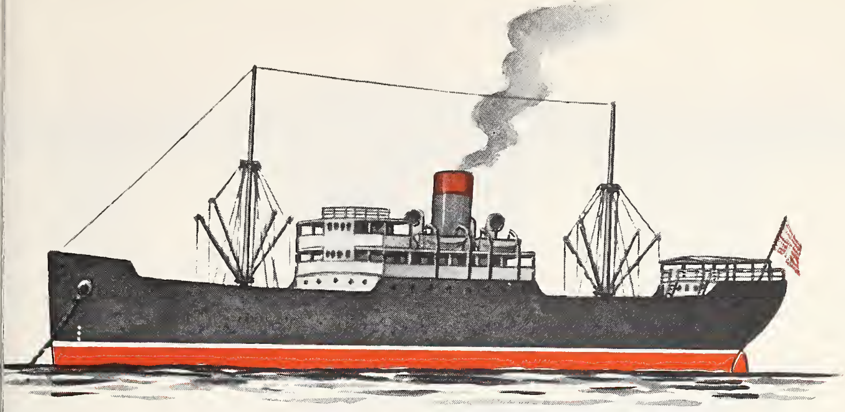
Look at the boat in the picture above. It is floating high in the water because it is empty.

Look at the picture below. You see the same boat with a load in it. The boat is deeper in the water. What would happen if another person got into the boat?

From these two pictures you can see that the greater the load, the more of the boat there is under water. The boat acts like the can in the last experiment.

Bring a toy boat to school and experiment with it. Add a load of stones and see what happens. Try different loads.

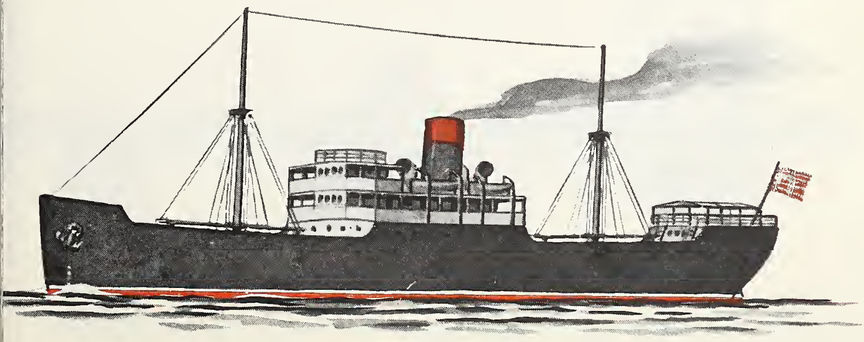


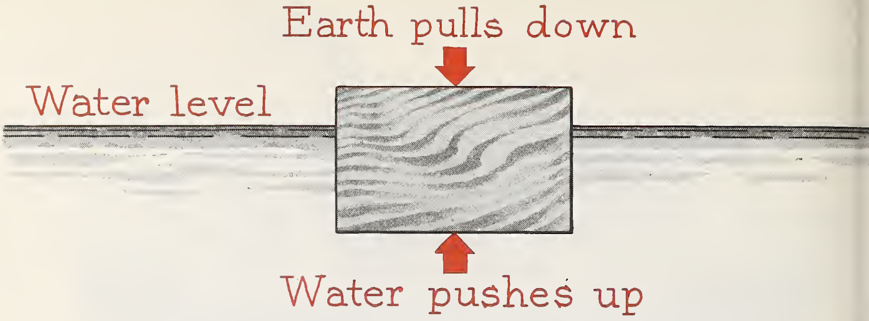


On this page there are two pictures of the same ship. In the top picture we know that the ship is not heavily loaded because it floats so high in the water.

In the lower picture we know that the ship must be heavily loaded. More of the ship is under water now. A ship that is heavily loaded floats low in the water.

Ships often have lines painted near one end. These lines tell how much a ship has been loaded. They are like the lines you painted on the can in the last experiment.



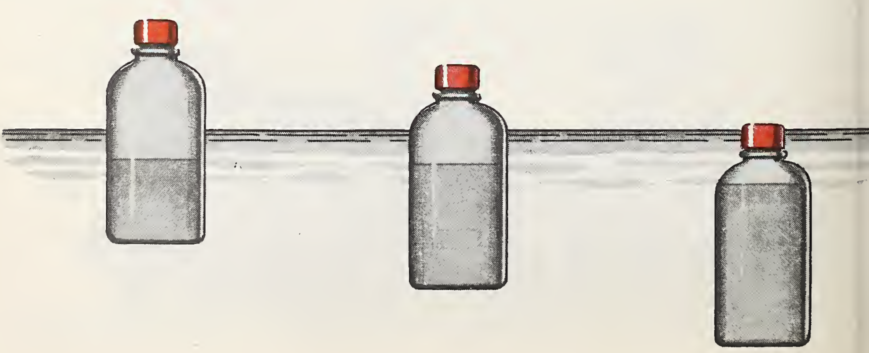


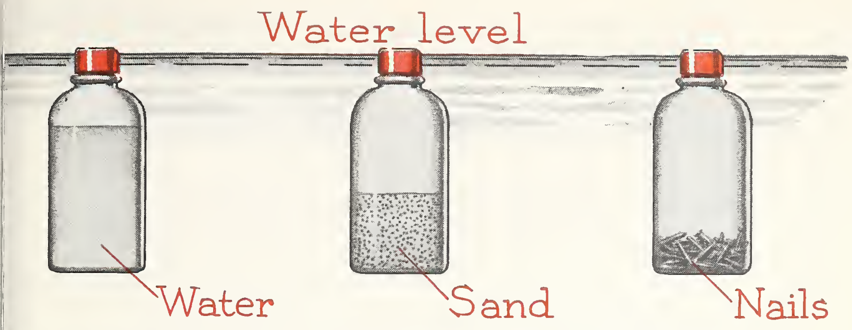
## Changing the Upward Force

Things float because water pushes up on them. A block floats if the water pushes up as much as the earth pulls down on it. What happens if the earth pulls down more than the water pushes up?

Weigh an empty bottle and its cap. Float the bottle. The water pushes up on it as much as the earth pulls down on it. How much is the upward force of the water?

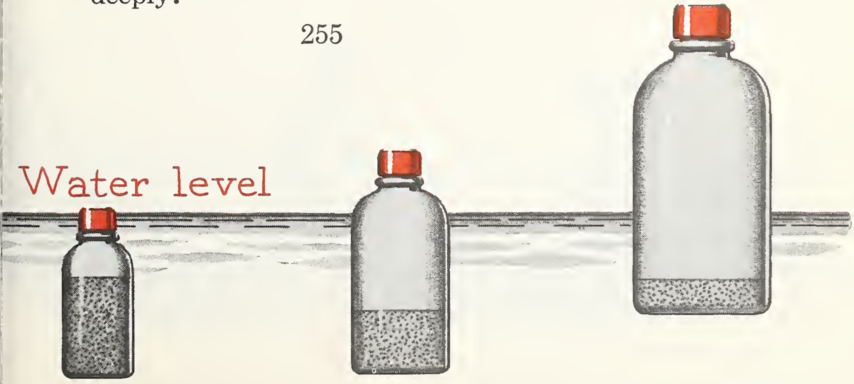
Add water until the bottle just floats. Weigh the bottle. What is the upward force when it is floating? What will happen if you add more water to the bottle?

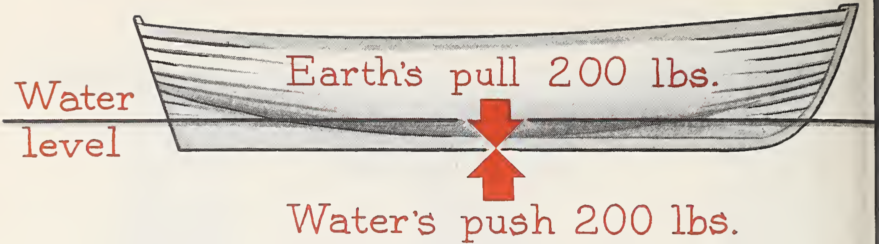




Put water in a bottle until it just floats and then weigh it. Pour out the water and put sand in the bottle until it just floats. Weigh it again. Try nails and other things. Does the kind of load make any difference in the upward push of the water?

Find three bottles of different sizes. Put sand in the smallest bottle until it just floats. Then weigh the bottle and the sand. Put sand in the other two bottles until all three bottles weigh the same. Then put them in water and notice how they float. Why don't the larger bottles sink as deeply?

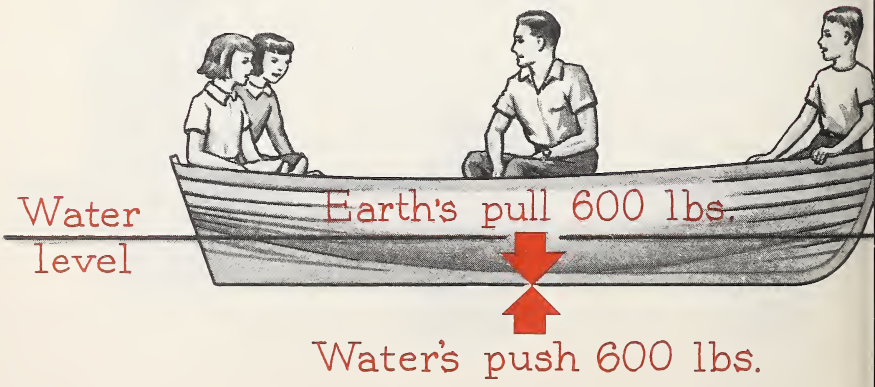


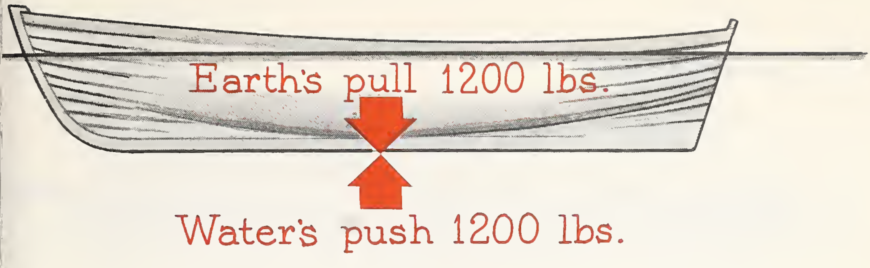


## Why a Boat Floats

A boat floats because the water pushes up on it. The more of the boat that is under water, the greater is the upward force.

The boat in the picture weighs 200 pounds. Only a little of it is under water. Suppose that we load the boat so that it weighs 600 pounds. The water must push up more now to balance the greater pull of the earth. The boat sinks deeper until the upward force becomes 600 pounds.



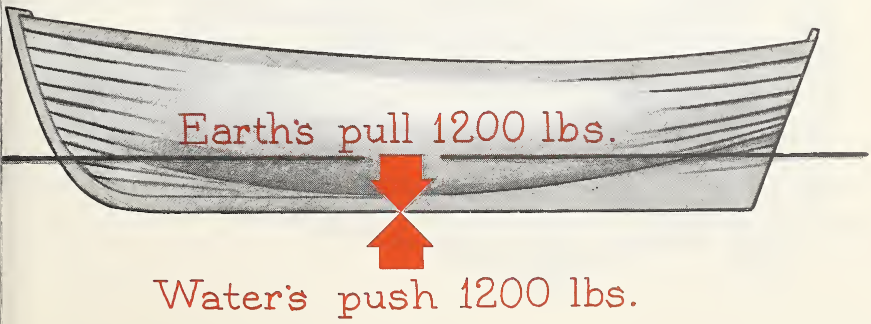


Suppose that we put sand in the boat until it just floats and the boat now weighs 1200 pounds. All of the boat is under water except for a tiny bit at the top. The upward force on the boat is 1200 pounds.

The boat will sink if we put any more sand in it. The upward force cannot be more than 1200 pounds.

If we needed to carry more than 1200 pounds we would have to use a larger boat. A larger boat can carry a bigger load because there can be more of the boat under water.

Find two toy boats of different sizes. Load the smaller one with sand until it just floats. Then put this load in the larger boat. Can the larger boat carry more? Why?

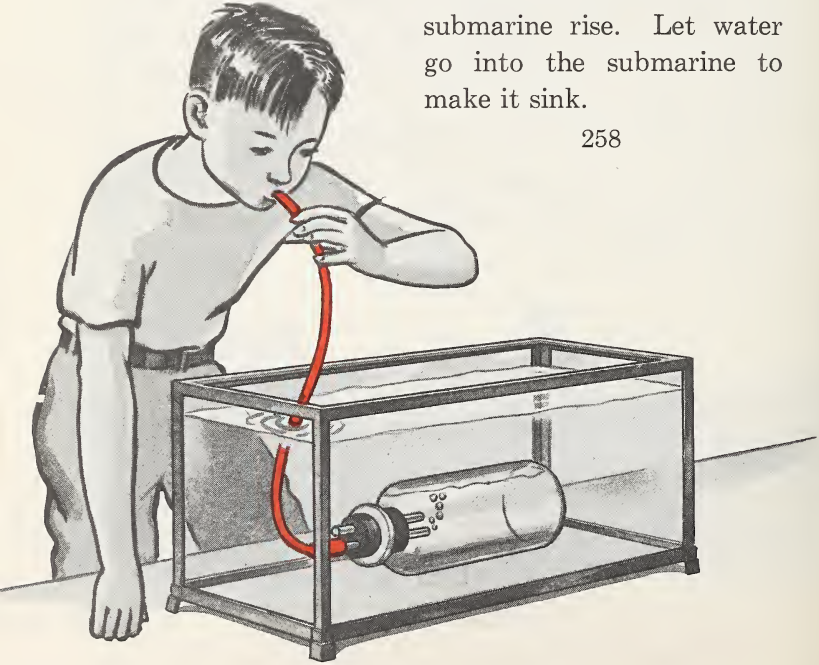


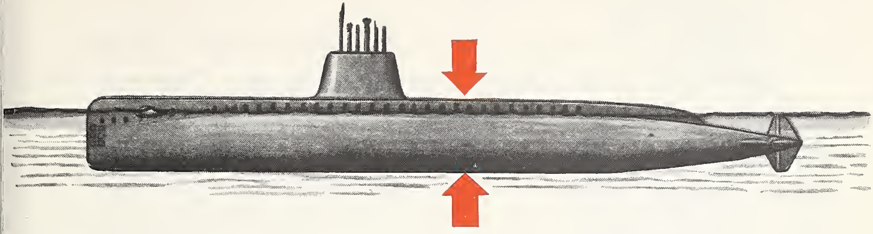
## Submarines

The captain of a submarine can make it float or he can make it sink. He does this by changing the weight of the submarine.

He can pump water into tanks in the submarine. This makes the submarine weigh more than the water can push up. Then the submarine sinks. He can force the water from the tanks to make the submarine weigh less. Then the submarine rises.

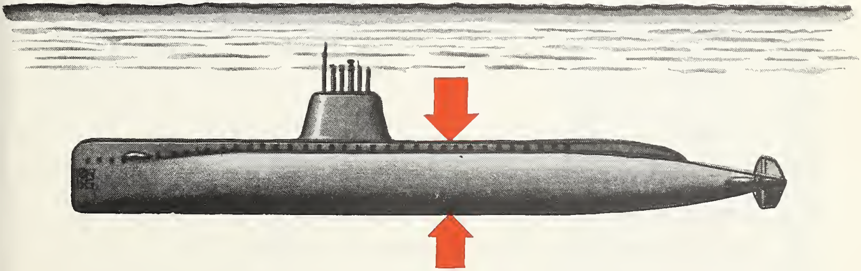
You can make a model submarine with a bottle, a piece of rubber tubing, two pieces of glass tubing, and a cork with two holes in it. Put it together as shown in the picture. Blow on the tube to make the submarine rise. Let water go into the submarine to make it sink.





In the top picture, the submarine has air in its tanks. It weighs less than when its tanks are full of water. If the submarine were at the bottom of the ocean, it would weigh less than the upward force of the water. What would happen?

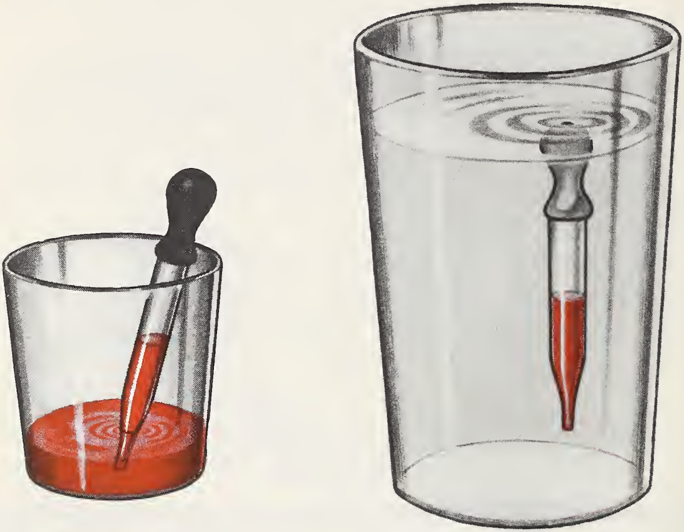
In the bottom picture the tanks are full of water. The submarine now weighs more than the upward force of the water. What is the submarine doing?



## A Submarine Diver

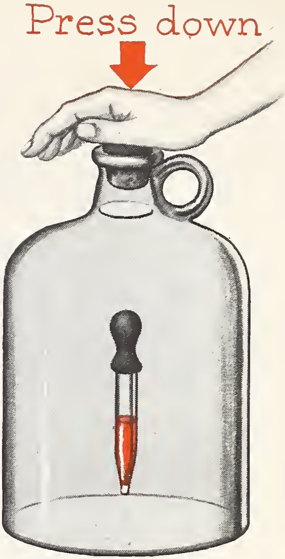
Colour some water with a few drops of ink. Draw some of the water into a medicine dropper. Then put the medicine dropper in water to see if it floats.

Draw in or force out coloured water until the medicine dropper just floats.



When the medicine dropper just floats, lift it out carefully and drop it into a large bottle filled with water. Press a cork lightly into the bottle.

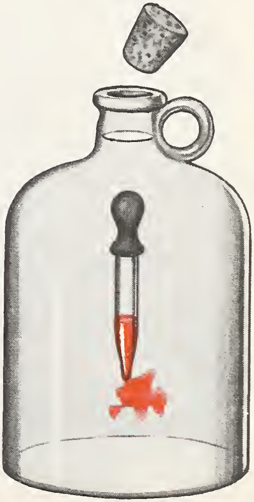
Now you have made a submarine diver.



Now press down hard on the cork. What happens?

Look closely at the medicine dropper. You will see that a little clear water was forced into the dropper. This is because some water was squeezed in when you pressed on the cork.

Does the dropper weigh more or less after the clear water goes inside it?



Now pull out the cork. What happens?

Look closely at the dropper. What has happened? What did this do to the weight of the dropper?

Can you explain now why the diver goes up and down?

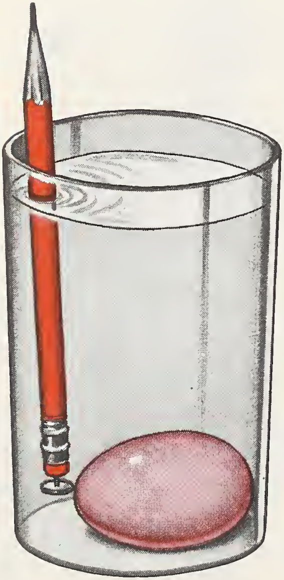
## Floating in Salt Water

Dissolve as much salt as you can in a jar of water. Let the salt that does not dissolve go to the bottom. Then pour off a glass of salt water.

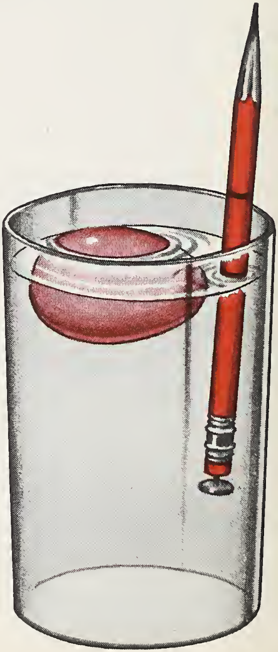
Push a thumb tack in the eraser of a pencil. Drop the pencil in a glass of fresh water. Mark the place where the water line comes.

Put the pencil in the glass of salt water. Is the water line in the same place? Does salt water or fresh water push up more?

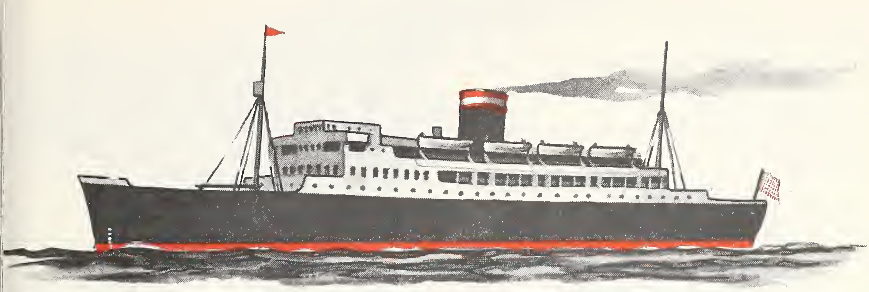
Put an egg in fresh water and then in salt water. What happens?



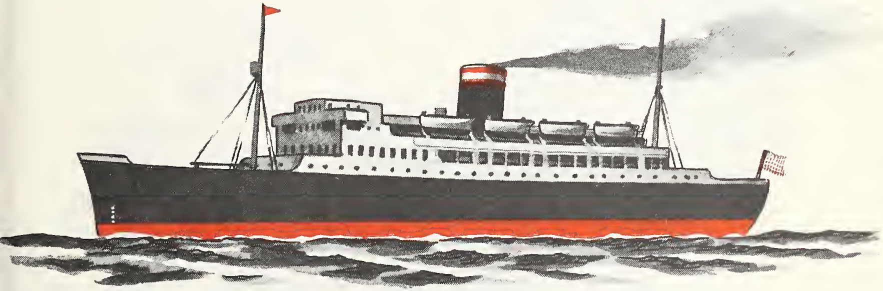
Fresh water



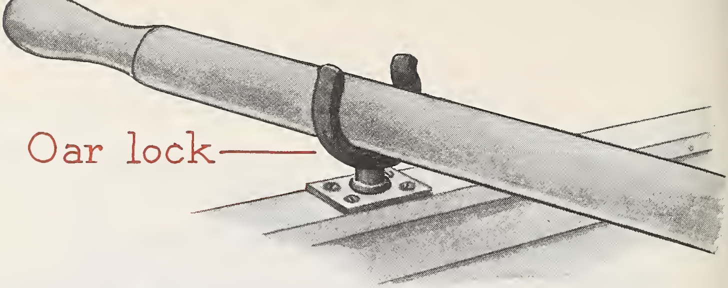
Salt water



This ship is going down a river. The water in the river is fresh water. Notice the painted line on the ship.



Now the ship has reached the ocean. Ocean water is salt water. Notice the painted line on the ship. Salt water pushes up on things more than fresh water does.

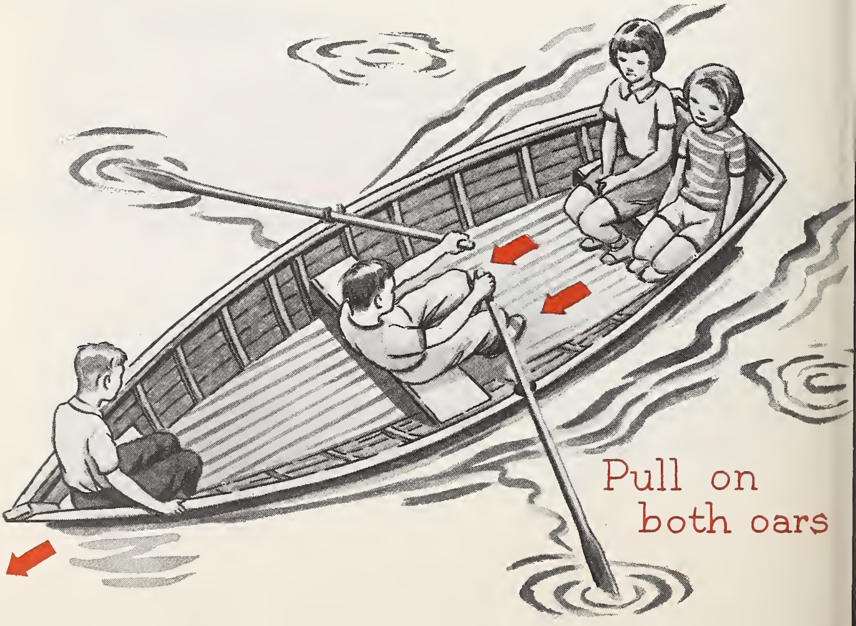


## Rowing a Boat

Everyone should know how to row a boat. It is not hard to do. These pictures will help you understand the right way to do it.

The person who rows faces the back of the boat. He pulls on the handles of the oars. The oars are levers that push on the water. This push moves the boat ahead.

He pulls on each oar with the same force to make the boat go in a straight line.

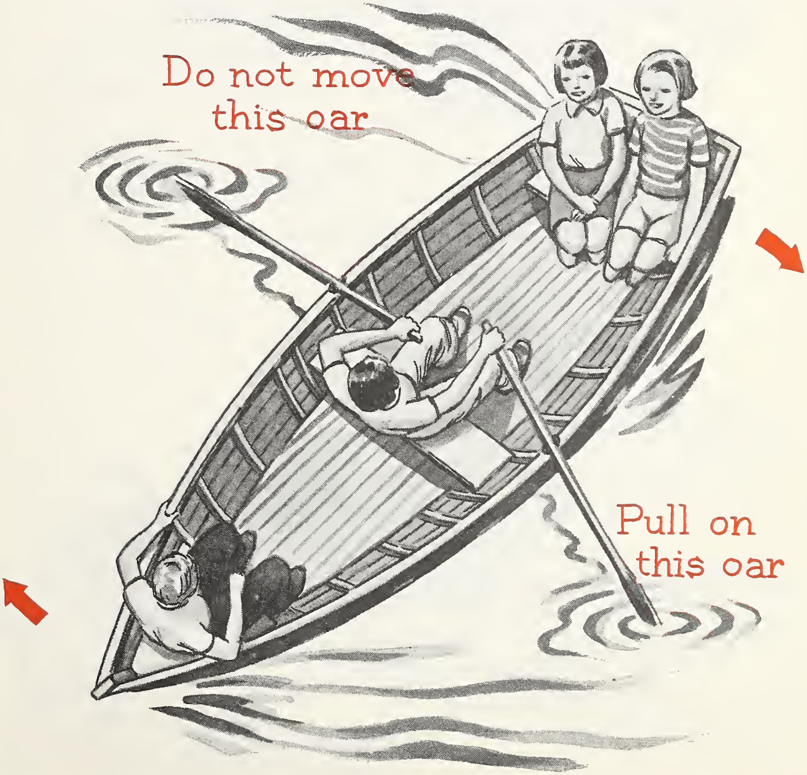


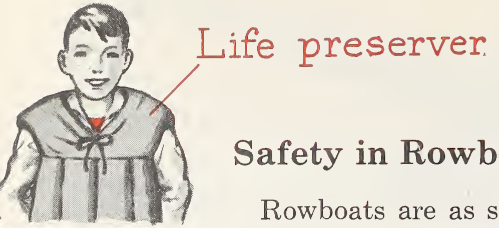
He pulls harder on one oar when he wants to turn. When he pulls harder on his right oar, the boat turns toward his left. Can you explain why?

What must he do if he wants the boat to turn toward his right?

Sometimes he wants to turn quickly. Then he holds one oar in the water, and pulls hard on the other oar. Tell how you would turn quickly to your left. Tell how you would turn quickly to your right.

Watch someone row a boat and see how he does it.


Do not move this oar
Pull on this oar



## Safety in Rowboats

Rowboats are as safe to ride in as automobiles if people are careful. Accidents happen only if people are careless.

Poor swimmers should wear life preservers when they are in a rowboat. They should ride only with people who can swim and handle a rowboat carefully.

Good swimmers must be careful, too. They should not take a boat far from shore without taking a life preserver for each person. Why?

People should not take rowboats out if there is danger of storms. Why is a windstorm dangerous? Why is a thunderstorm dangerous?

People should not take rowboats where large motorboats and ships travel. How can a fast motorboat tip over a rowboat without hitting it?

Don't overload a rowboat. Why?

Don't tip a rowboat. Why?

Don't move around in a rowboat. Why?

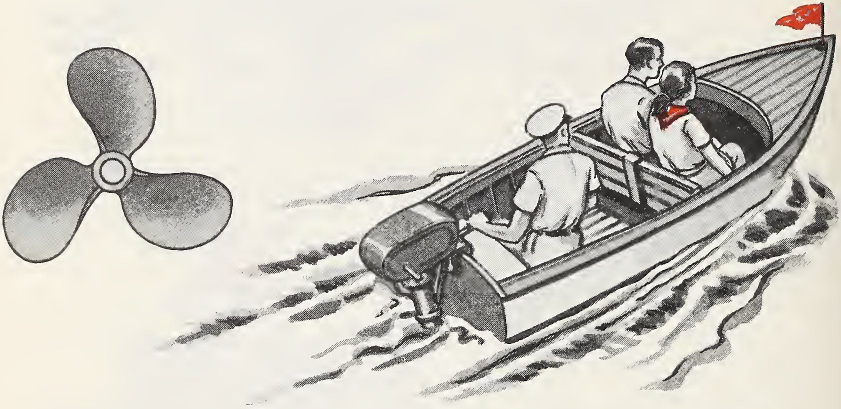
What are some more rules for safety in a rowboat? List as many as you can.

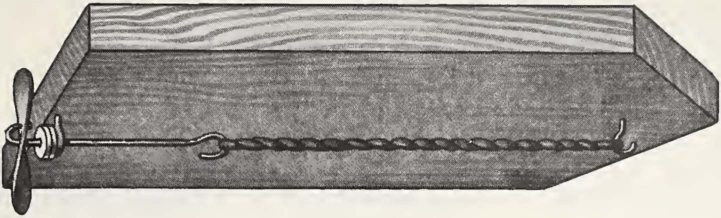
## Boats with Propellers

Nearly all motorboats and big ships are moved through the water with propellers. The propeller of a boat is shaped something like the propeller of an airplane.

A propeller is turned by an engine. The propeller pushes back on the water as it turns. This makes the boat go ahead.

Motorboats need energy to make them move. Where do they get their energy?





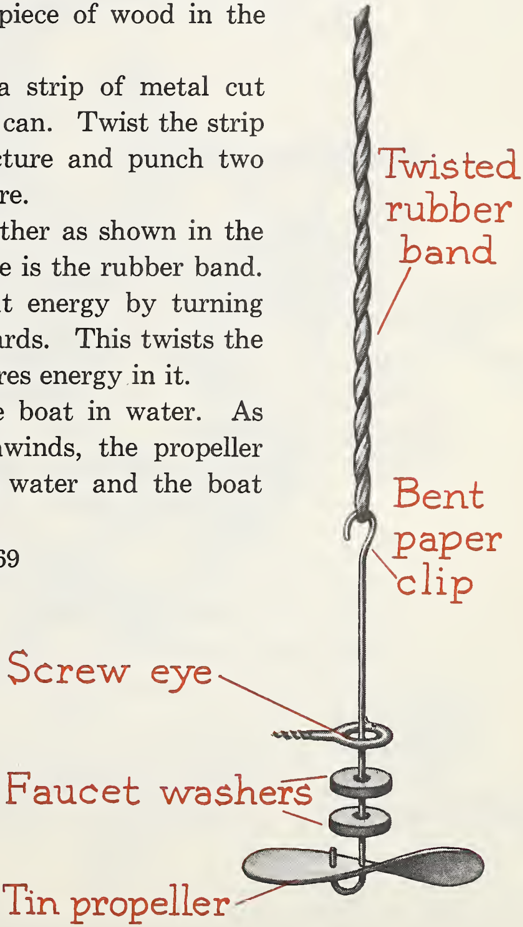
This page shows how to make a toy motorboat. Cut a piece of wood in the shape shown above.

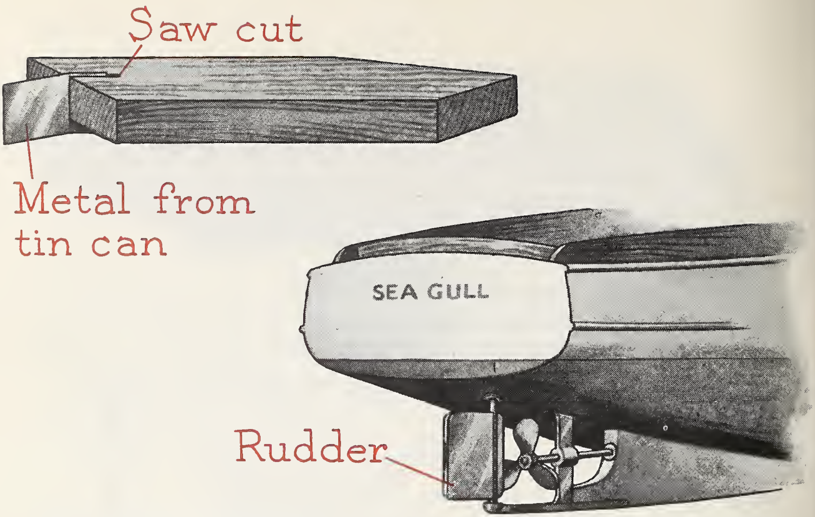
The propeller is a strip of metal cut from the lid of a tin can. Twist the strip as shown in the picture and punch two holes in it for the wire.

Put the boat together as shown in the pictures. The engine is the rubber band.

You give the boat energy by turning the propeller backwards. This twists the rubber band and stores energy in it.

Then you put the boat in water. As the rubber band unwinds, the propeller pushes back on the water and the boat moves.





## Steering a Boat

A boat can be steered with a rudder. Cut a piece of wood in the shape of a boat. Use a fine saw to make a cut in the back of the boat. Cut a piece of metal from a tin can for the rudder and push it into the cut at the back of the boat as shown in the picture.

Push the boat in water and notice what happens. Bend the rudder to one side and try the boat in water again. Explain how the rudder turns the boat.

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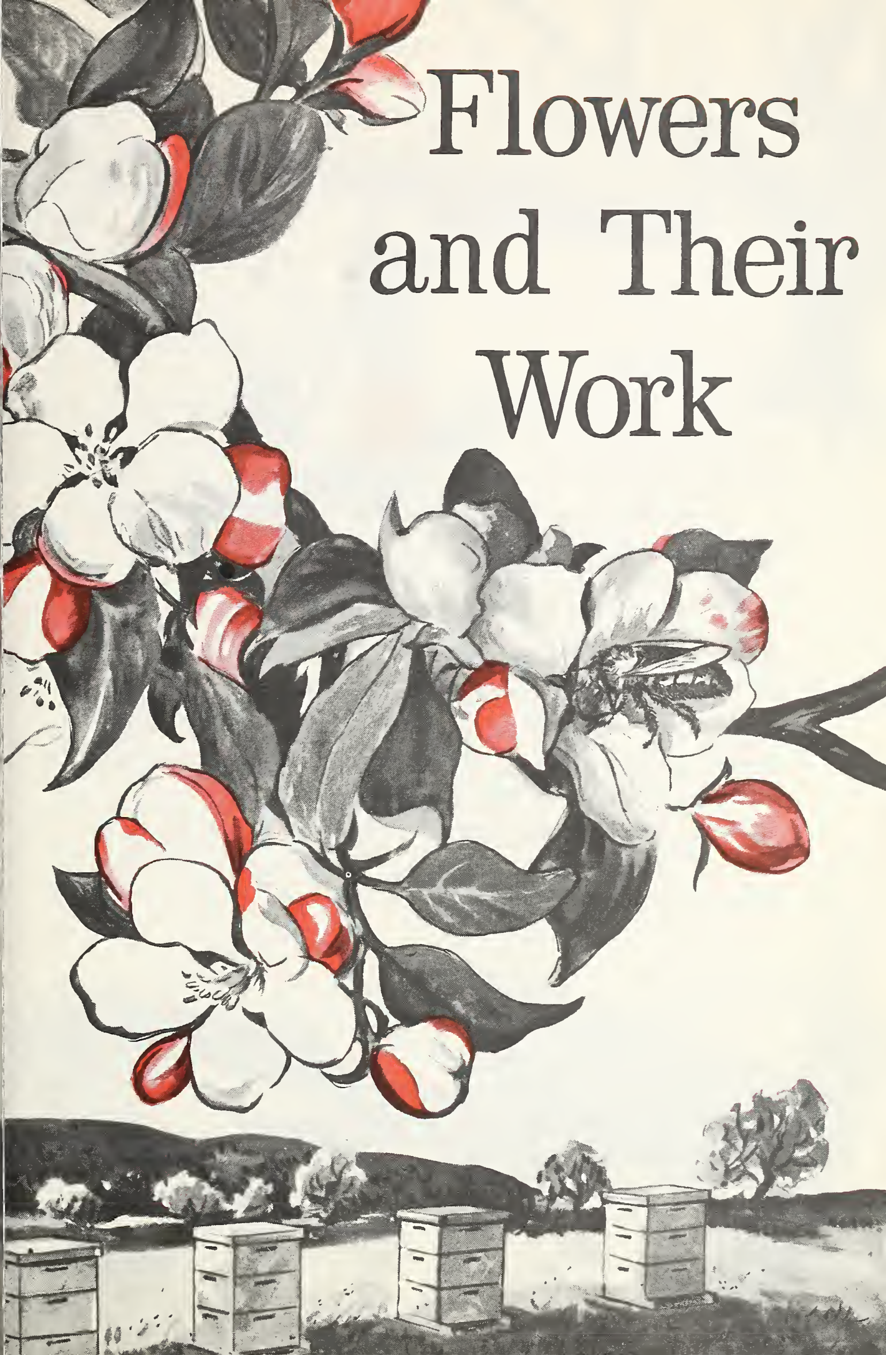
1. Why do boats float?
2. What makes a submarine rise and sink?
3. How can you make a rowboat turn?
4. What does a motorboat propeller do?
5. What happens when a ship sails from fresh water to salt water?
6. What are some rules for safety in a rowboat?
7. Why can a big boat carry more than a small boat?

# Flowers and Their Work

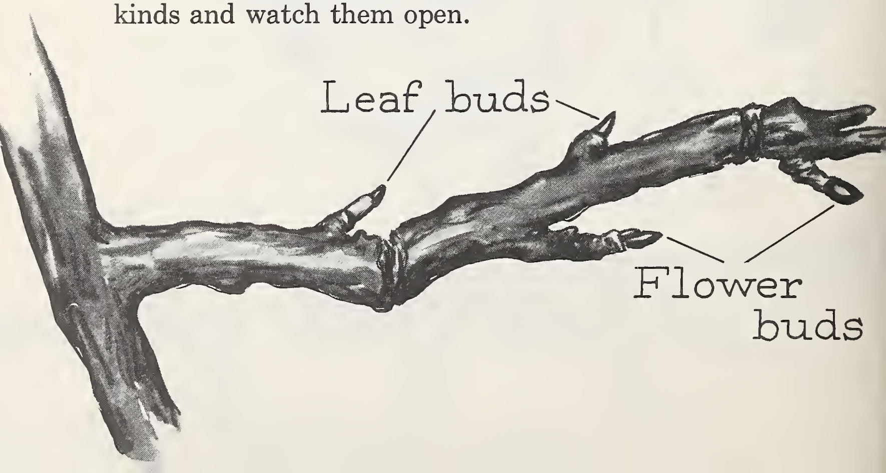


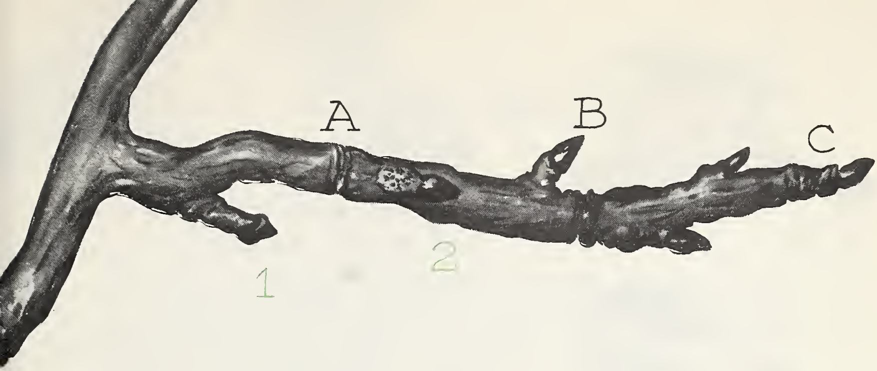
## Flowers from Buds

All winter the buds on the apple trees have looked dead. But when warm weather comes the buds begin to open. Leaves and flowers grow from the buds.

You can tell leaf buds from flower buds by their shapes. Leaf buds are small and pointed. Buds with flowers inside are larger and round.

Bring some apple twigs to school and put them in water. Watch the buds open. Bring in buds of other kinds and watch them open.



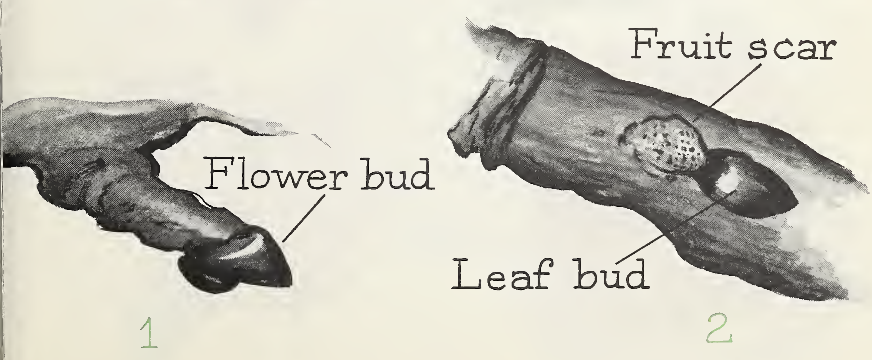


An apple twig like this one tells a story. The rings at A, B, and C show where the twig stopped growing each fall. Last year the twig grew from B to C. What part grew the year before? How old is the twig?

Flowers will come from some of the buds. Which ones? Leaves will come from some of the buds. Which ones?

Look at bud number 2 below. There is a scar beside it. The scar shows where an apple grew last year. Sometimes there are several little scars instead of one big one. Then we know that flowers grew there but none of them became apples.

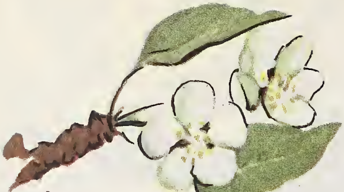
Find some apple twigs and read their stories.



## Flowers and Fruit

Watch some apple flowers this spring. You will see that the petals soon fall off. The rest of the flower stays on the twig. The part of the flower that stays on the tree becomes the apple. Look at an apple and find some of these parts. Cut open an apple and find the seeds.

Some people think that plants have flowers in order to be beautiful. But as you study flowers, you will see that their work is to make seeds and fruit.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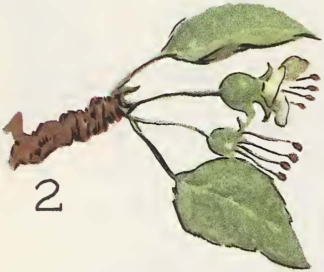
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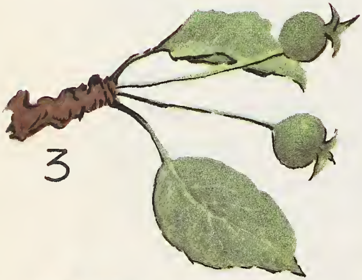
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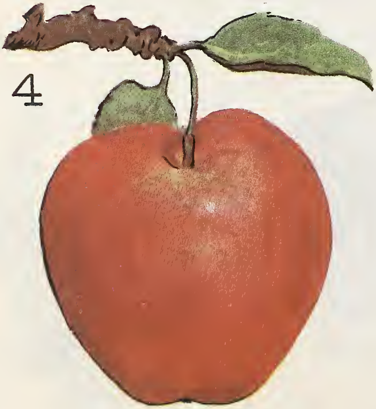
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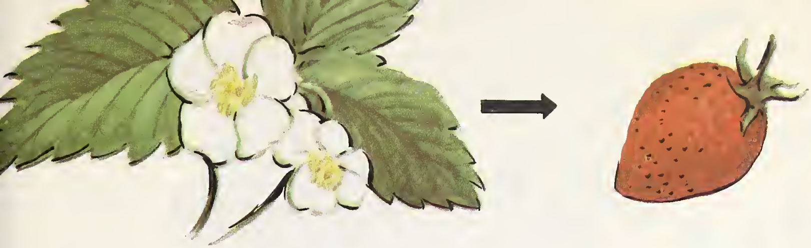
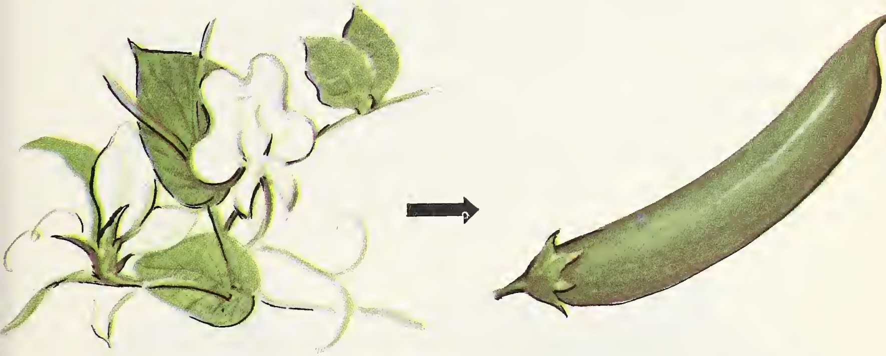
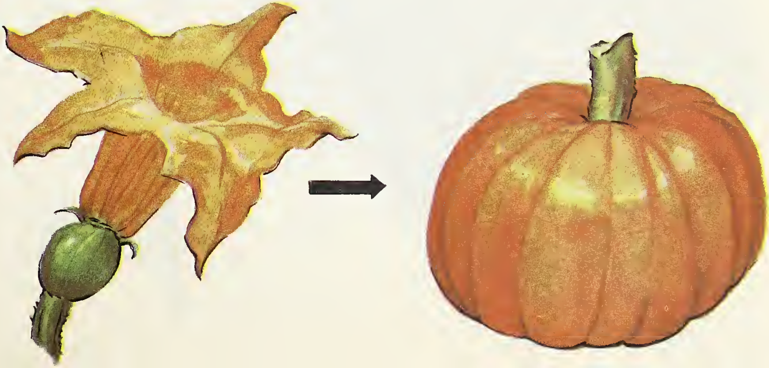


Watch the flowers of different kinds of plants. You will often see the flowers change into fruits. Some parts of the flowers die and drop off. Other parts grow larger and become the fruits.

Fruits of garden plants are often called vegetables. They are really fruits if they come from flowers and have seeds inside.



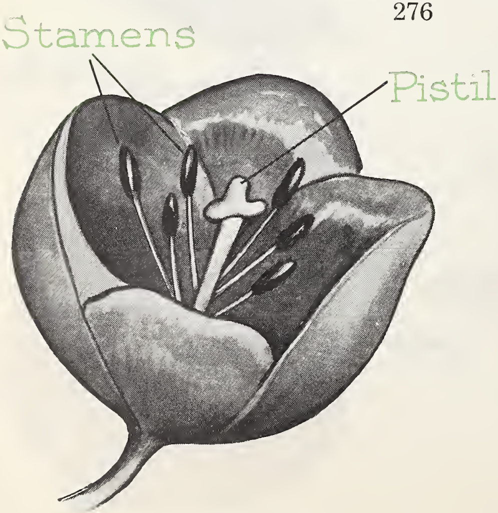


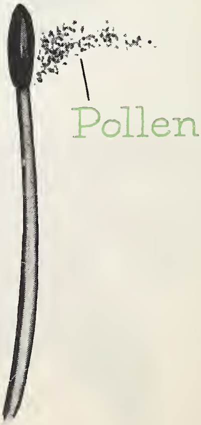
## Parts of Flowers

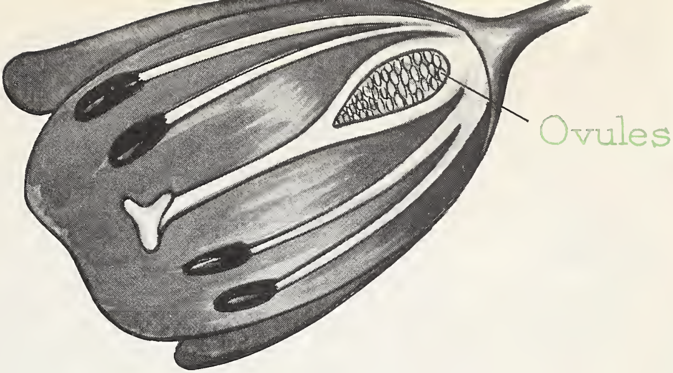
Look at the picture at the bottom of the page and then look at a tulip or other large flower. Can you find the **stamens?** Can you find the **pistil?**

Touch the end of one of the stamens. Notice the powder that comes off on your finger if the stamen is ripe. This powder is called pollen.

Some flowers have more than one pistil. Some flowers have a different number of stamens. Look for the stamens and the pistils in other kinds of flowers.



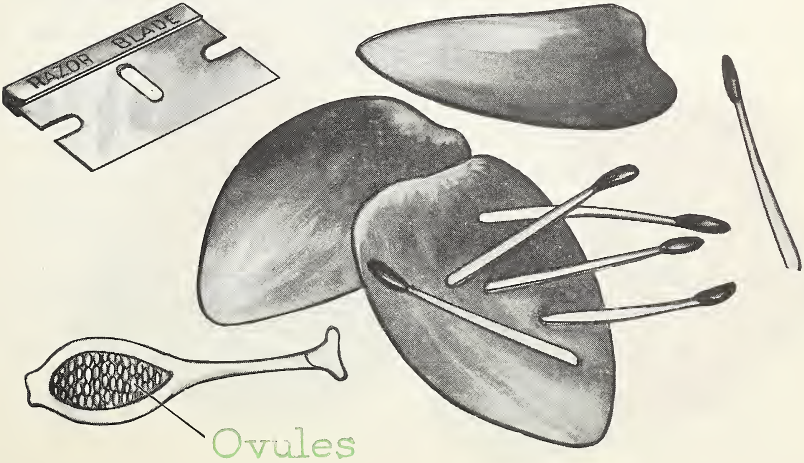


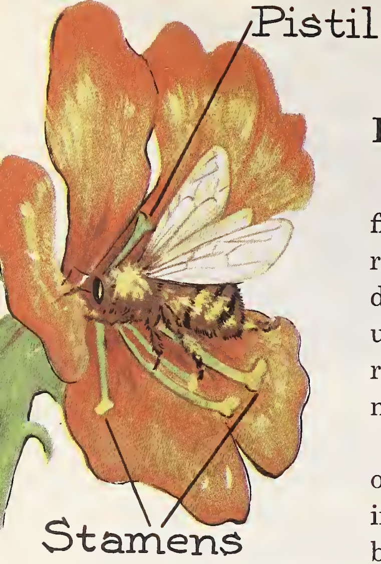


Cut open the pistil of a large flower such as a tulip. Use a razor blade or a sharp knife and cut it as shown in the pictures.

Notice the tiny balls growing inside the pistil. These are called **ovules.** Take some out and look at them. These ovules might have become the seeds of the tulip plant.

All seeds start as ovules. Peas were once ovules in the pistils of pea flowers. Beans were ovules in the the pistils of bean flowers.





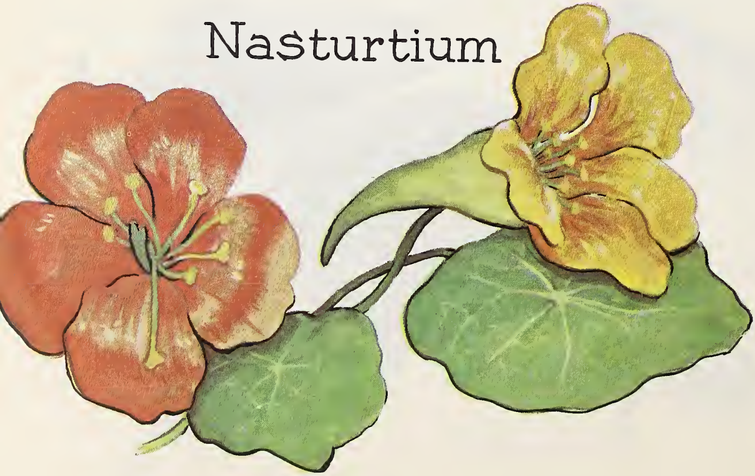
## Bees and Flowers

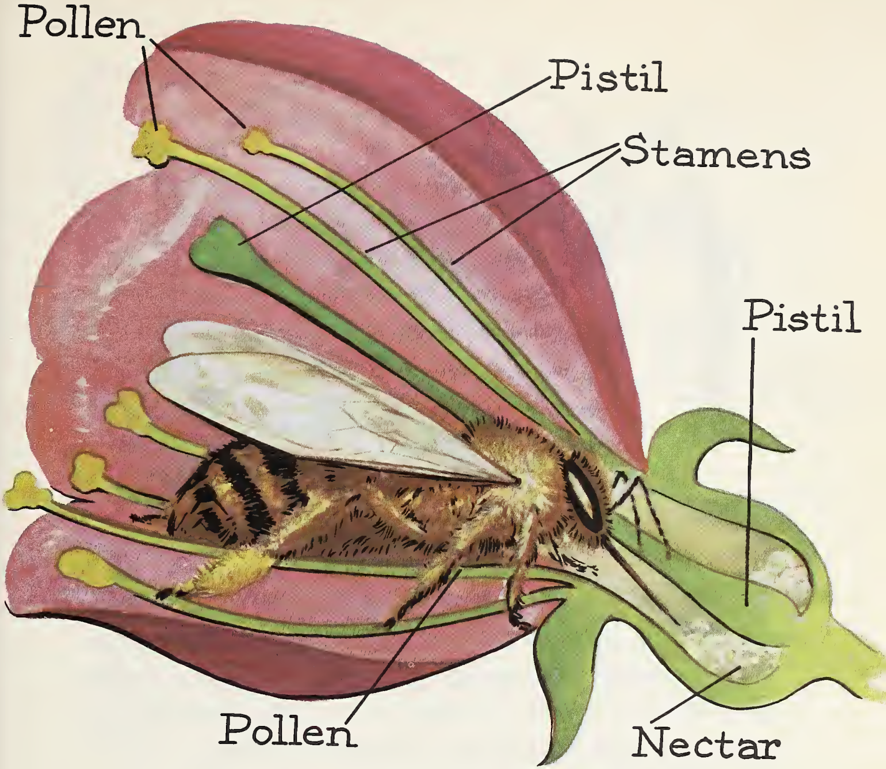
Bees visit many kinds of flowers to get nectar. You will remember that nectar has sugar dissolved in it and that the bees use the sugar for food. Can you remember how they change the nectar to honey?

Flowers like the ones below often have large drops of nectar in the deepest parts. You can break off the end of the flower and suck out the nectar.

Many flowers have bright colours. Many have sweet scents. Perhaps these colours and scents help bees find the flowers.

Watch a bee in a flower bed. Does it go from flower to flower of the same kind? Does it visit different kinds of flowers?

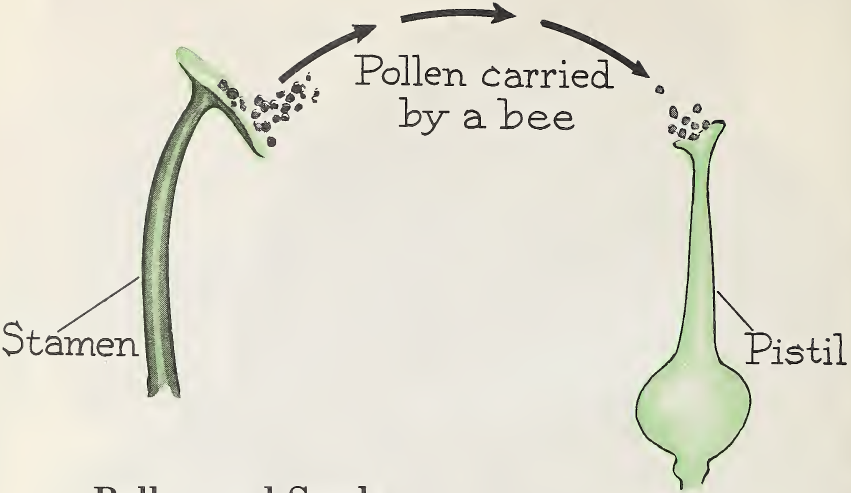




When a bee crawls into a flower it rubs against the stamens of the flower. Pollen comes off the stamens and sticks to the hairy body of the bee.

When the bee visits another flower, some of the pollen on its body rubs off on the pistil of this flower. The bee's body picks up more pollen from the stamens of the flower.

Thus the bee carries pollen from one flower to another as it goes about looking for nectar. We will see that pollen-carrying is important to the plants.

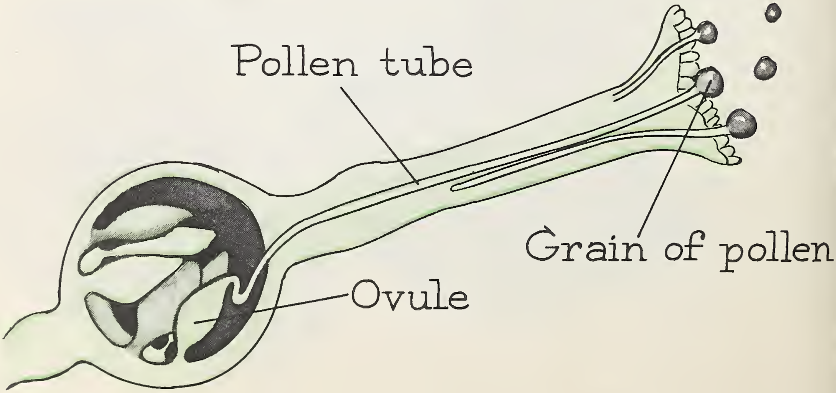


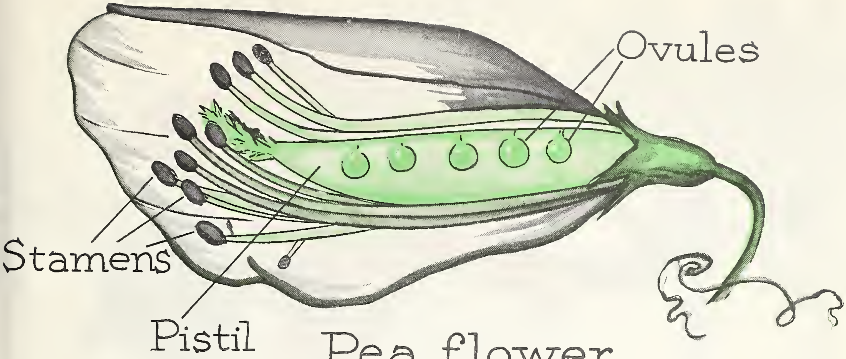
## Pollen and Seeds

Pollen is usually needed before ovules can become seeds. The pictures on this page show what happens.

Pollen is carried from the stamen of one flower to the pistil of another flower. A tiny tube grows from a grain of pollen through the centre of the pistil. It grows until it comes to an ovule.

Then part of the grain of pollen goes through the tube into the ovule. The ovule is now ready to grow into a seed.





Pea flower

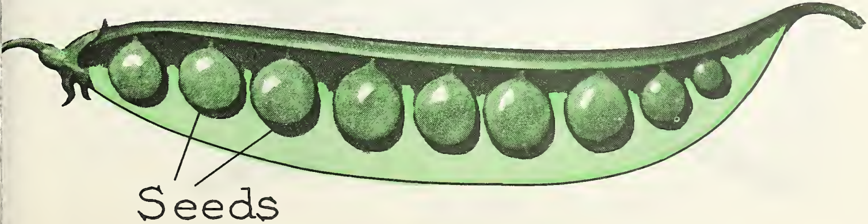
In the flower of a pea plant, the pistil looks like a tiny pea pod. There are ovules inside the pistil.

Bees visit the flower looking for nectar. They may then carry pollen from that flower to another one. Some of this pollen may stick to the end of a pistil. Then a tube grows from each grain of pollen to an ovule inside the pistil.

The ovules now begin to grow into seeds. The pistil grows and becomes the pea pod. After a few weeks there is a pea pod full of peas. The pod and the peas are the fruit of the plant.

Often you will find in pea pods some ovules that did not become seeds. Perhaps no pollen tubes reached these ovules.

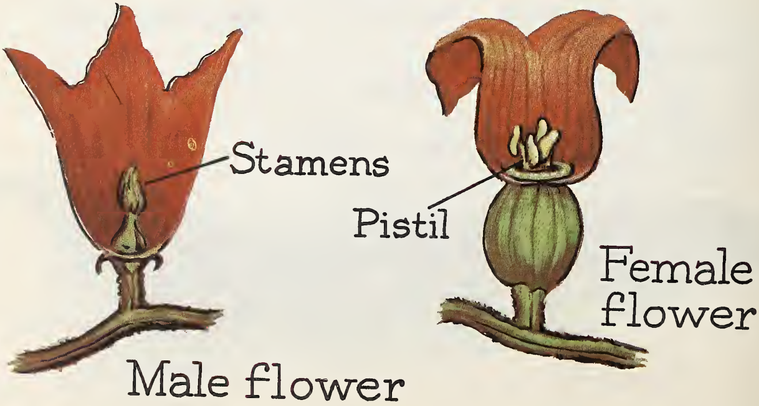
Pea fruit



## Male and Female Flowers

A pumpkin plant has two kinds of flowers. Some flowers have only stamens and we call them male flowers. Some flowers have only pistils and we call them female flowers. Which flowers give off pollen? Which flowers have ovules?

Only the female flowers become pumpkins. Many people think the other flowers are of no use. Why are both kinds of flowers needed?

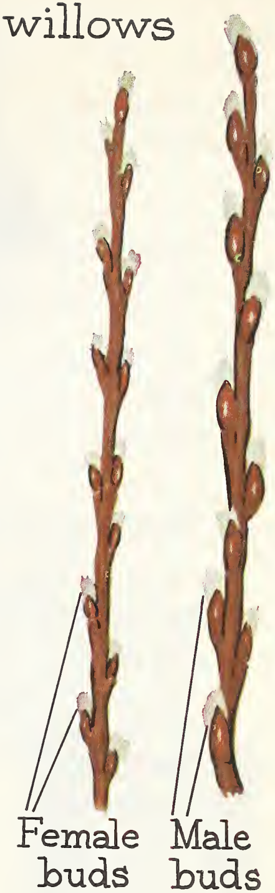


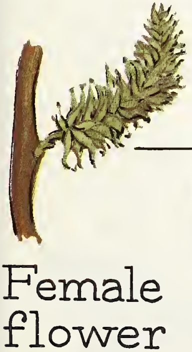
# Pussy willows

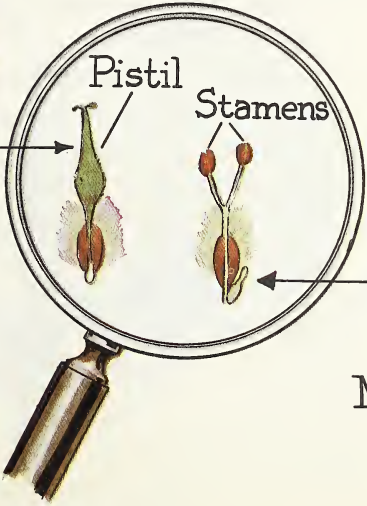
Pussy willows have two kinds of flowers, too. These flowers grow on different bushes. Male flowers grow on one bush. Female flowers grow on another bush.

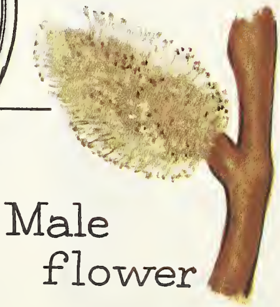
The buds of the male flowers are larger than the female buds. The male flowers are more beautiful, and most people bring in the twigs of the male pussy willows to watch them blossom.

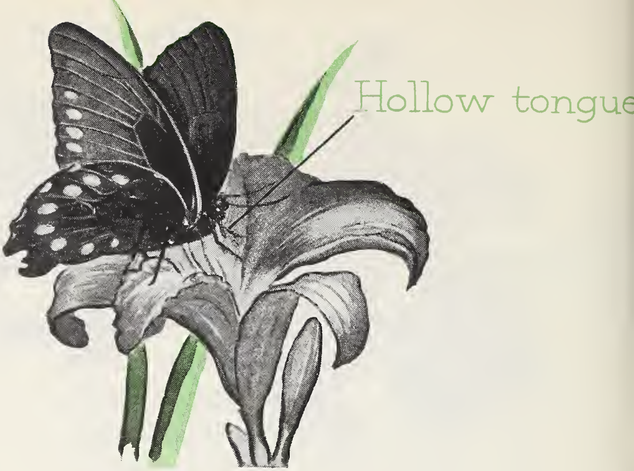
Flowers of cottonwood trees and poplar trees are much like the flowers of pussy willows. Look for them and see if you can find both male flowers and female flowers.









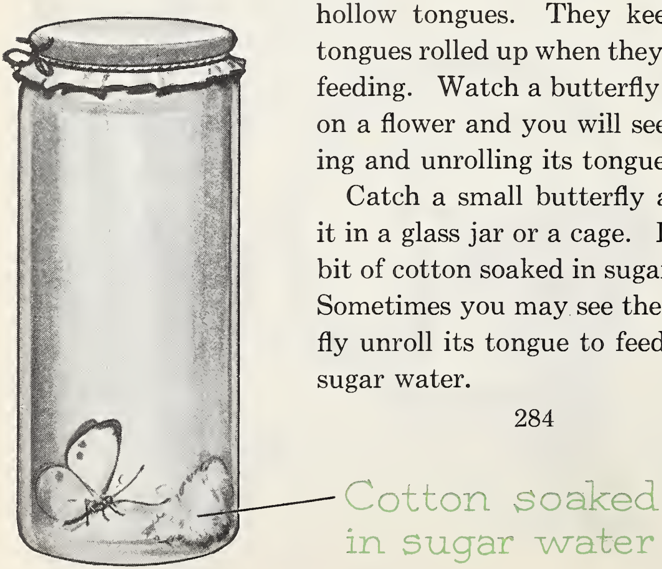


## Moths and Butterflies Carry Pollen

Many moths and butterflies feed upon the nectar of flowers. They sometimes carry pollen from one flower to another.

Moths and butterflies have long, hollow tongues. They keep their tongues rolled up when they are not feeding. Watch a butterfly feeding on a flower and you will see it rolling and unrolling its tongue.

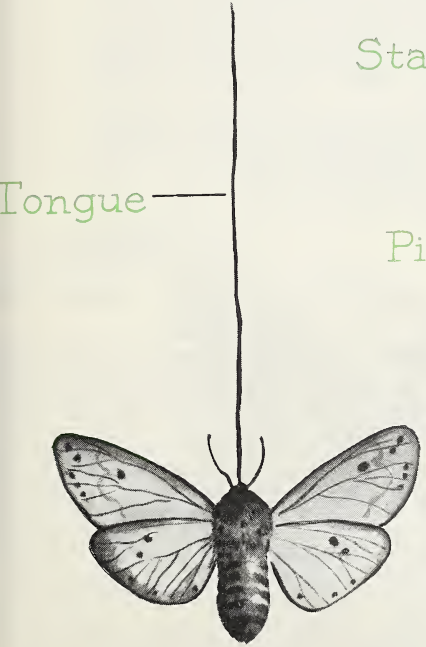
Catch a small butterfly and put it in a glass jar or a cage. Put in a bit of cotton soaked in sugar water. Sometimes you may see the butterfly unroll its tongue to feed on the sugar water.


Cotton soaked in sugar water

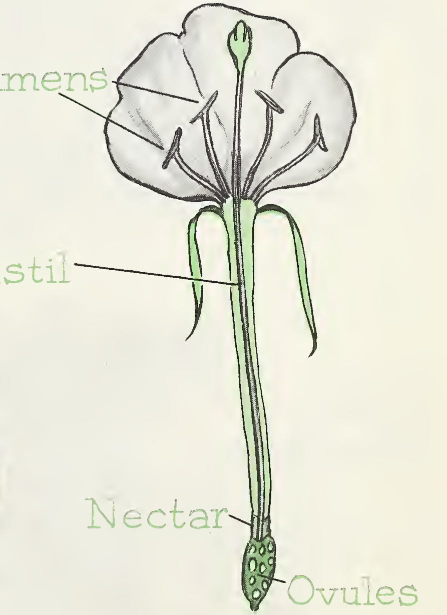
Bees do not visit evening primroses. Their tongues are not long enough to reach the nectar at the bottom of the flowers.

Butterflies and moths have long tongues. The sphinx moth has a tongue several times as long as its body. It can reach the nectar in an evening primrose easily.

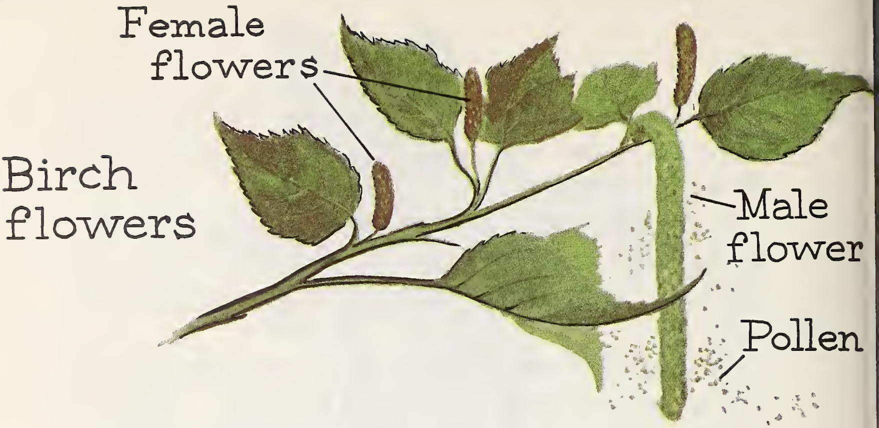
The pollen of many flowers such as the evening primrose is carried only by moths and butterflies. If there were no moths and butterflies, the ovules of these plants would not become seeds.



Tiger moth



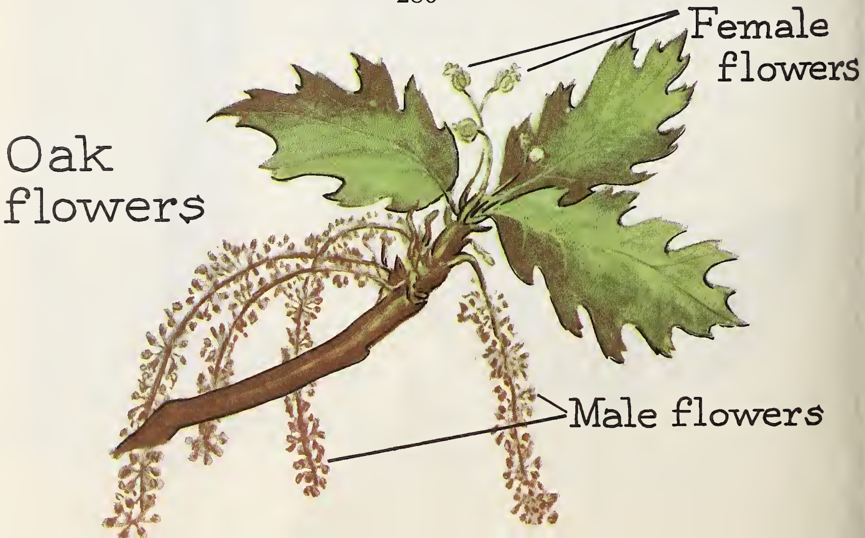
Evening primrose

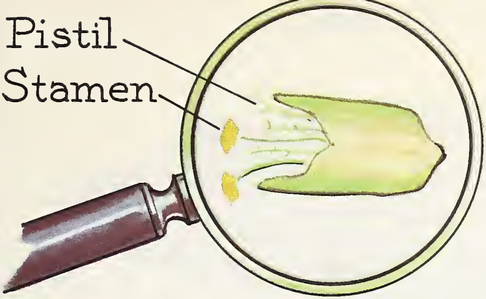


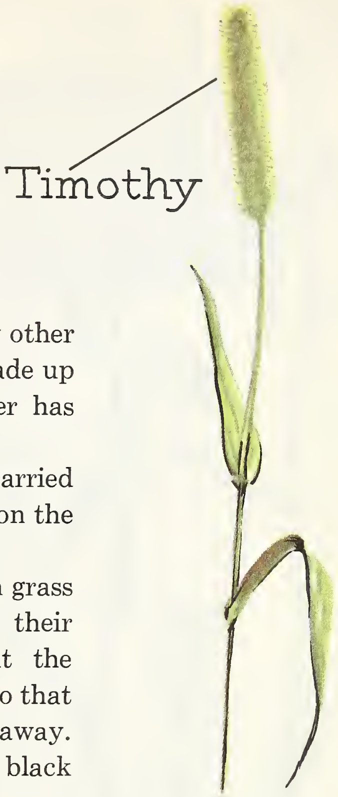
## Pollen Carried by the Wind

Many plants do not need insects to carry their pollen. The pollen of these plants falls from the stamens of the flowers. Then the wind carries it to the pistils of other flowers. The pollen of many trees is carried by the wind. Twigs of two of these trees are shown on this page. Look for others.

Flowers like these are not brightly coloured. They have no sweet scents. They have no nectar.



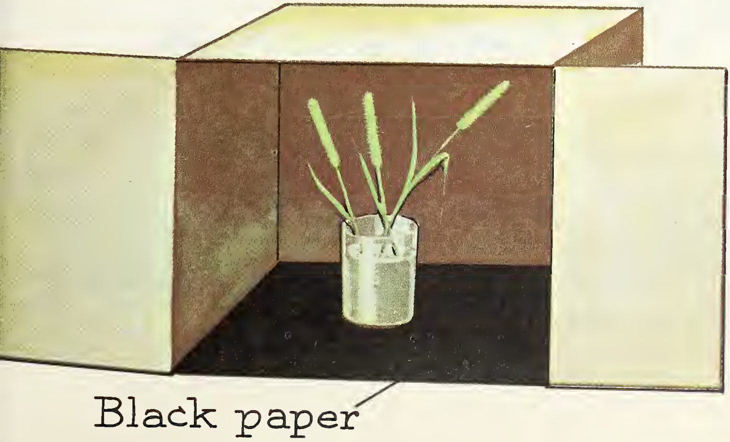


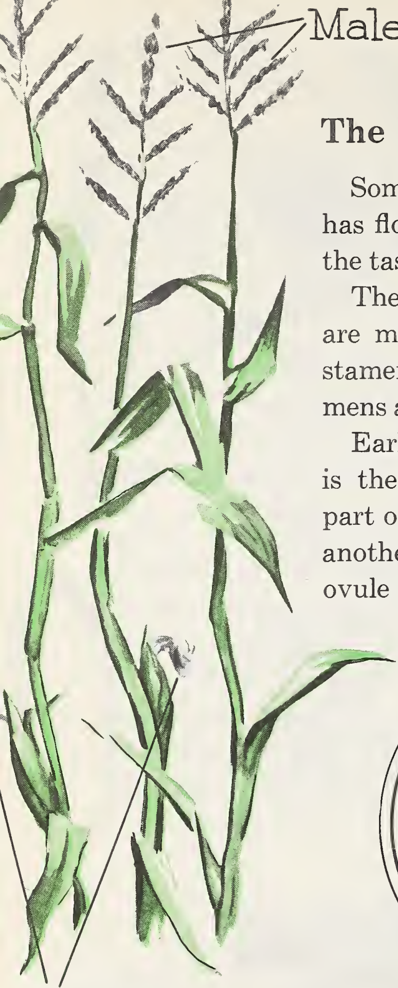


Grasses have flowers just as many other plants do. Each head of grass is made up of many tiny flowers. Each flower has stamens and pistils.

The pollen from the stamens is carried away by the wind. Some of it falls on the pistils of the same kind of grasses.

Here is a way to catch pollen from grass flowers and other plants that have their pollen carried by the wind. Put the flowers in the box and close the box so that wind does not carry the pollen away. You will find the pollen on the black paper.



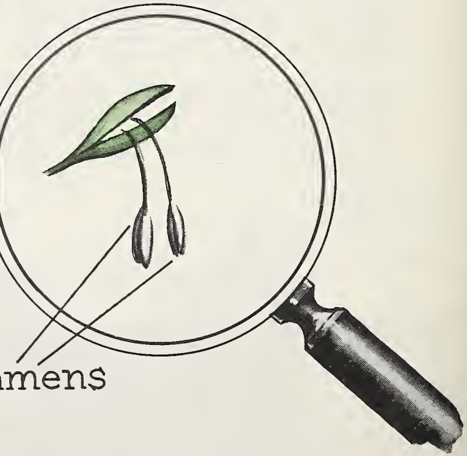


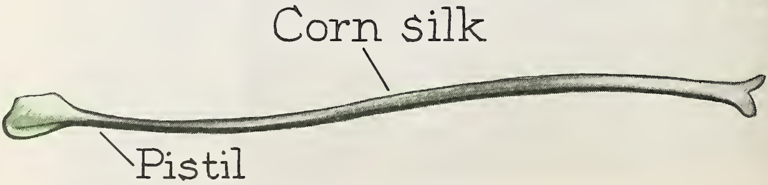
## The Flowers of Corn

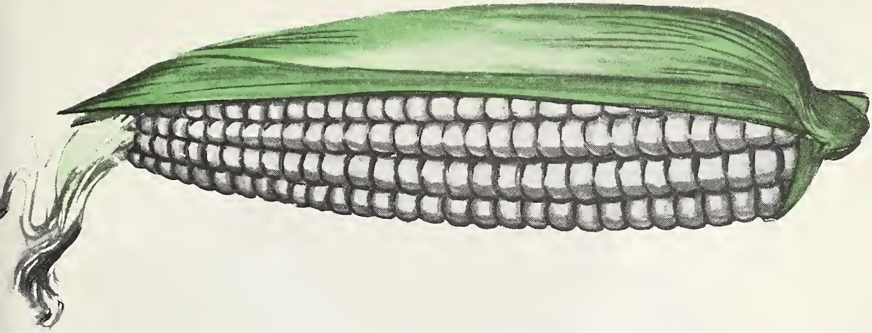
Some people do not know that corn has flowers. They do not know that the tassels and the ears are flowers.

The tassels at the tops of the stalks are male flowers. They have many stamens. Pollen drops from the stamens and is carried away by the wind.

Early in the season, an ear of corn is the flower. Each grain inside is part of a pistil. Each thread of silk is another part of the pistil. There is an ovule inside each grain.



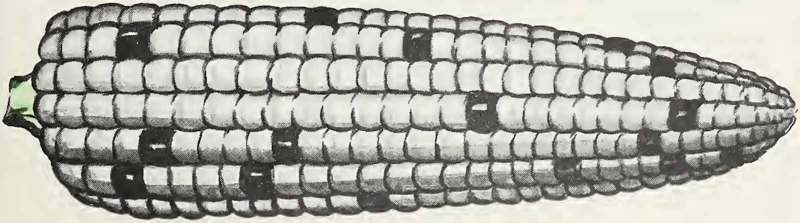




Suppose a grain of pollen falls on a thread of corn silk. A tube grows from the grain of pollen through the thread to the ovule at the other end. Then the ovule grows into a seed inside the grain of corn.

In most ears of corn there are usually some ovules that do not become seeds. Can you tell why this may happen?

Below is a picture of an ear of corn that has grains of two different colours. This ear grew in a field of yellow corn. Some black corn grew in a field nearby. Wind carried pollen from the black corn to the yellow corn.



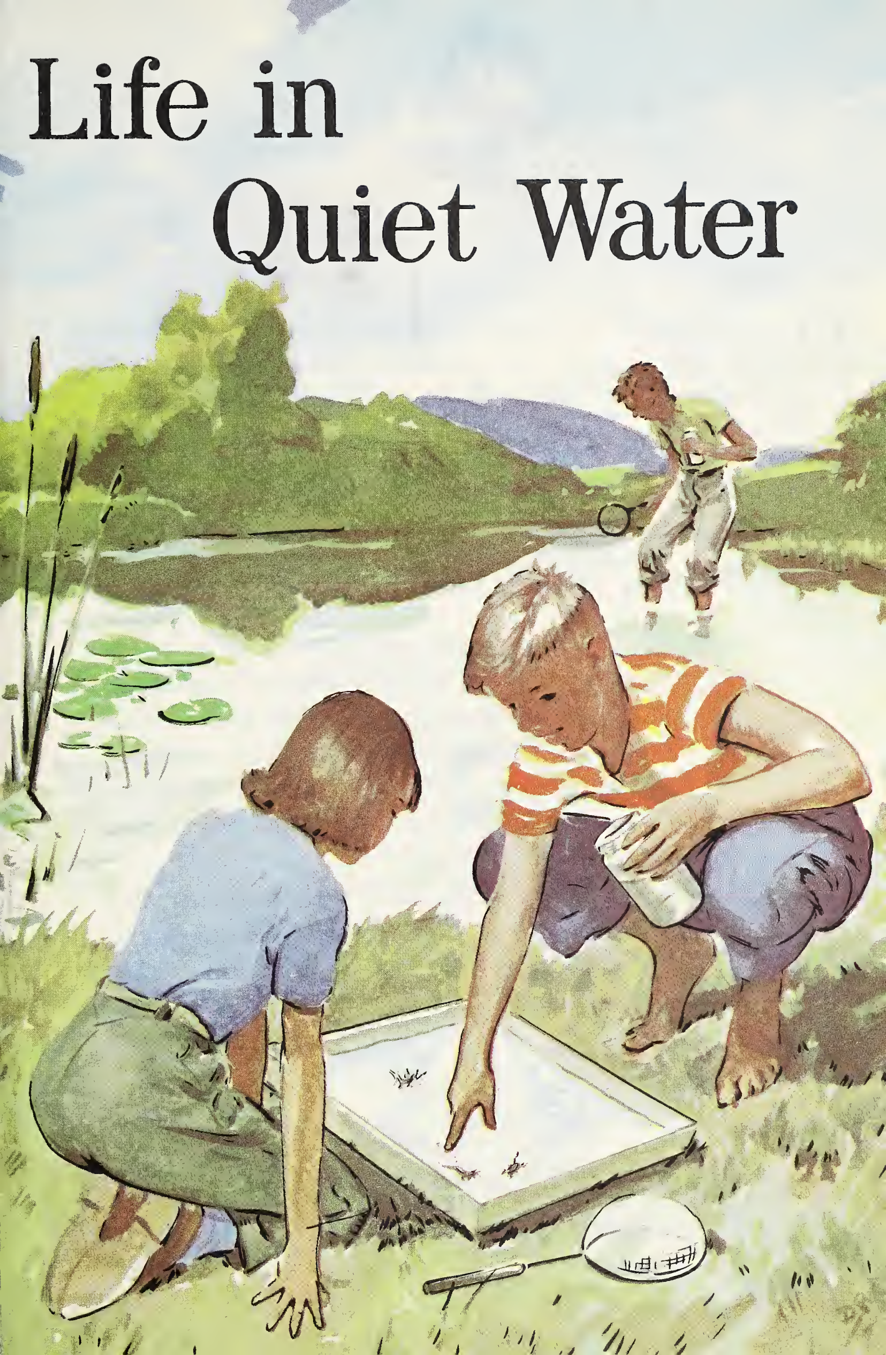
A farmer raised some green squash. His neighbour raised some yellow squash.

The next spring, the farmer planted some seeds from one of his green squashes. The squash that grew did not look like anything he had seen before. Pollen from one kind of squash had been carried to the pistils of another kind.

---

1. In what part of a flower do seeds grow?
2. Of what use is a stamen to a plant?
3. Why are bees important to many plants?
4. Name some plants whose pollen is carried by the wind.
5. Where are the flowers on a corn plant?
6. Why do some fruit farmers keep bees?
7. What is the difference between male flowers and female flowers?

# Life in Quiet Water

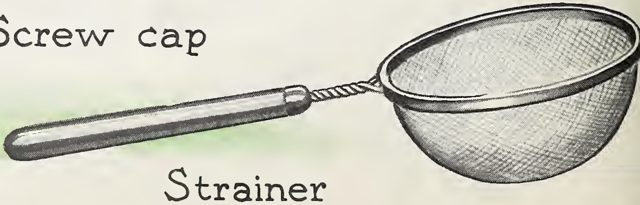


## Collecting Water Life

Many interesting plants and animals live in the water. You will find it fun to catch and study them.

The best places to collect water plants and animals are in ponds, slow streams, and ditches full of water. Try to find places where there are many plants growing in the water. There are usually many animals living among the plants.

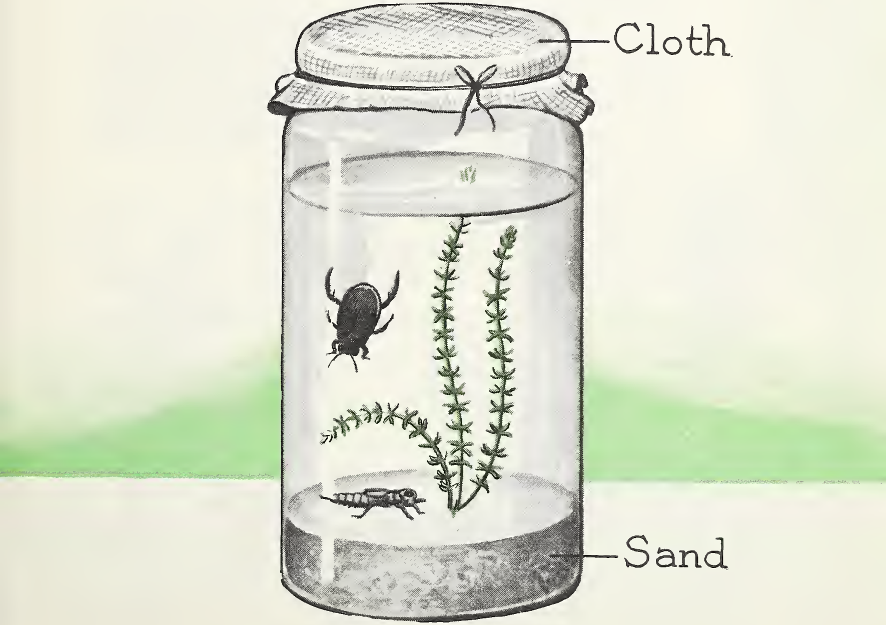
Take along a kitchen strainer and some glass jars with screw caps. A flat pan is also useful for studying the things that you catch.



Sweep the strainer through the water plants. Dump the strainer into a jar or a pan of water. You will usually see animals swimming about or hanging to the plants. Take some of these animals home.

Keep the animals in small aquariums. Glass jars make good aquariums. A piece of cloth over the top of each one keeps the insects from crawling out if they are the kind that can live in air.

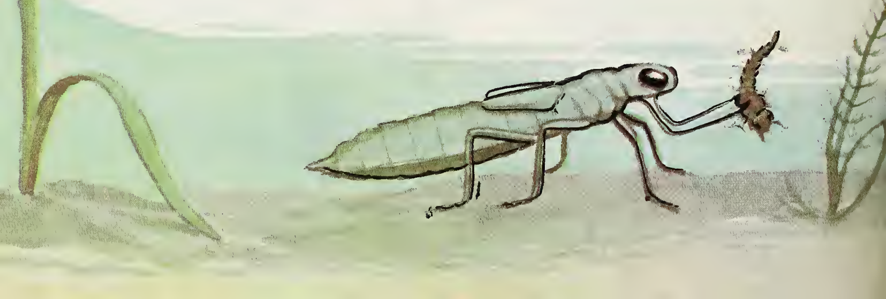
Put the aquariums on window sills where the sun does not shine on them. Watch the animals to see what they do.

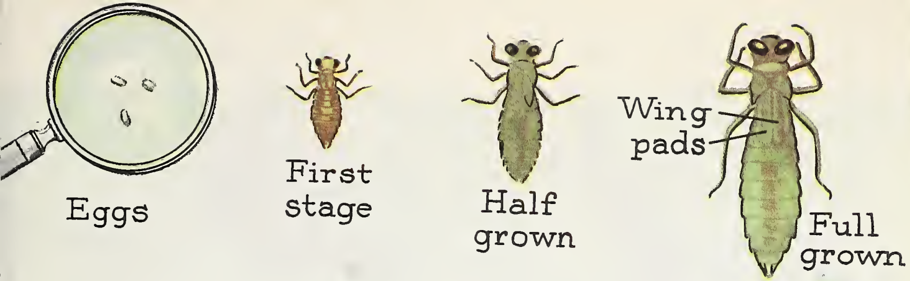


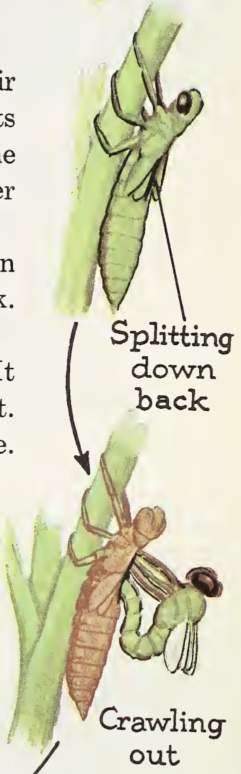
## Dragonflies

You may find young dragonflies among the animals that you caught. Young dragonflies do not look like their parents. They have no wings. They are usually dull in colour. They can live only in water.

Young dragonflies feed on smaller animals. Each dragonfly has a long, folded lower lip. There is a pair of pincers on the end of the lip. The young dragonfly snaps out this lower lip and catches small animals that pass nearby.



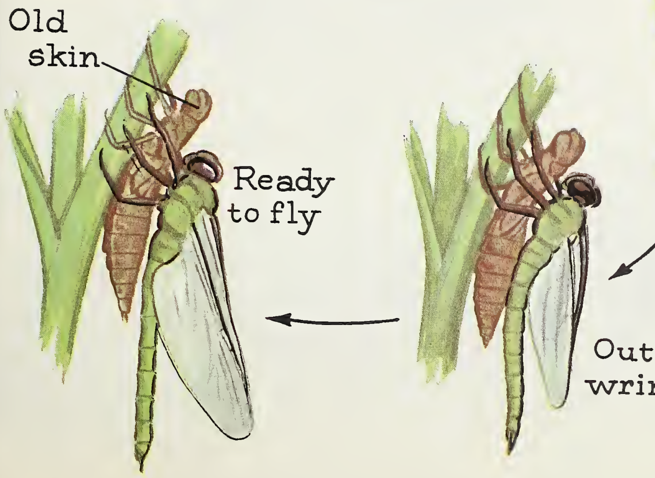


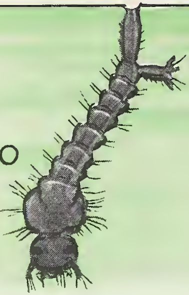


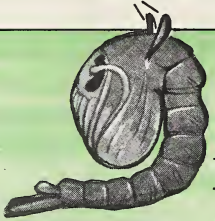
Young dragonflies grow by shedding their skins. When a young dragonfly has filled its skin, the skin splits down the back and the dragonfly crawls out. It has a new and larger skin that grew beneath the old skin.

After a young dragonfly has shed its skin several times, pads begin to grow on its back. There are wings growing inside these pads.

At last the young dragonfly is full grown. It crawls out of the water onto a stone or a plant. Its skin splits down the back for the last time. A winged dragonfly crawls out.





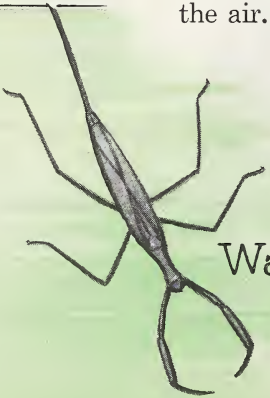


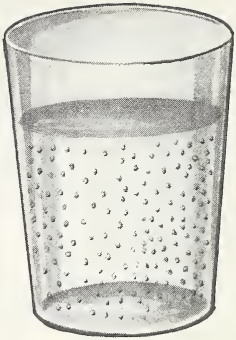
## Oxygen and Water Animals

All animals must have oxygen. They cannot live long without it. They need it so they can use the energy that is in their food.

Land animals have plenty of oxygen all around them. The air is about one-fifth oxygen. They get all the oxygen they need when they take air into their bodies.

Many water animals use the oxygen that is in the air. They come to the top of the water for the oxygen. Animals like frogs and turtles push their heads above water and breathe. Some other animals have breathing tubes they push out into the air.

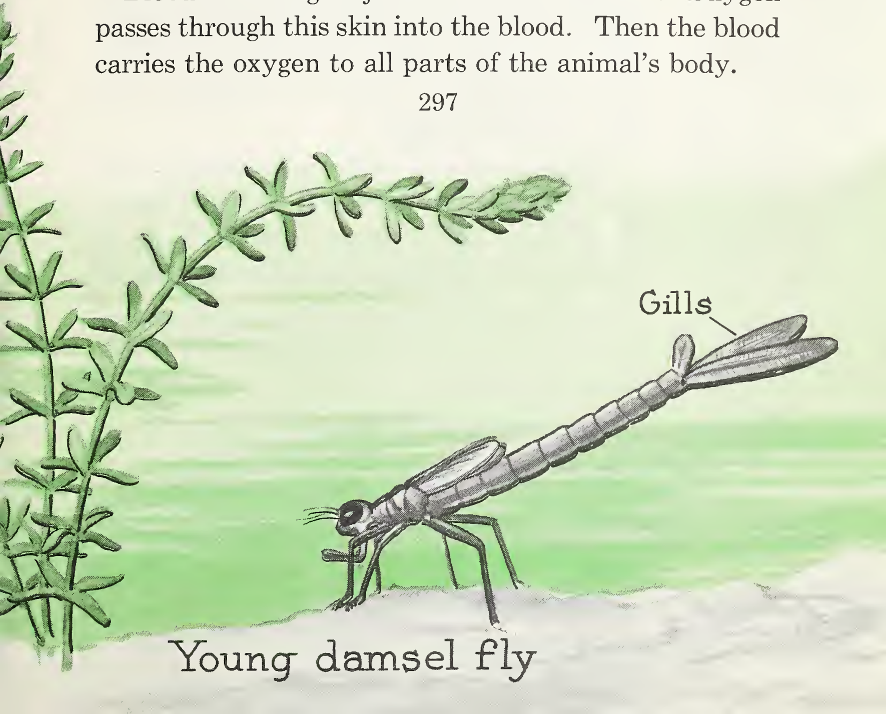




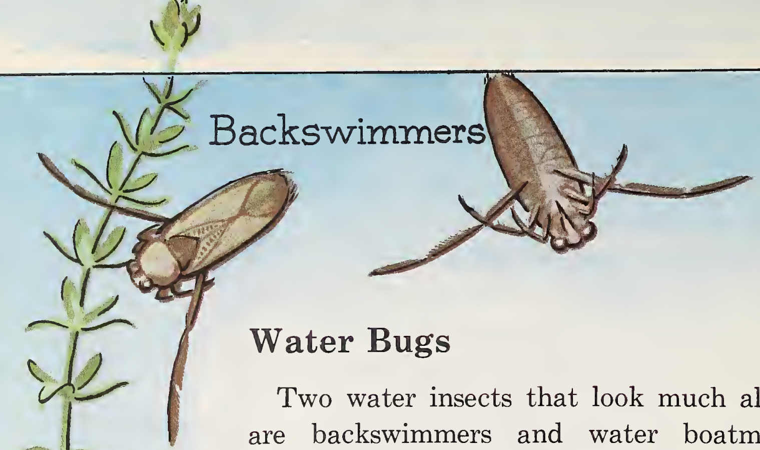
There is usually a little oxygen dissolved in water. Fill a drinking glass with cold water and let it stand in a warm room. Soon small bubbles collect on the inside of the glass. There is oxygen in these bubbles together with other gases. They were dissolved in the water.

Many water animals are able to use the oxygen that is dissolved in the water. Some of them have gills. Some of them take in the oxygen through their skin.

Blood flows in gills just beneath a thin skin. Oxygen passes through this skin into the blood. Then the blood carries the oxygen to all parts of the animal's body.



Young damsel fly



## Water Bugs

Two water insects that look much alike are backswimmers and water boatmen. Both insects are well named. A water boatman is shaped like a boat and it has a pair of legs that look like oars. Backswimmers swim upside down.

These insects spend most of their lives under water but they get their oxygen from the air. When they dive, they carry air down with them. The air is held by tiny hairs on their bodies.

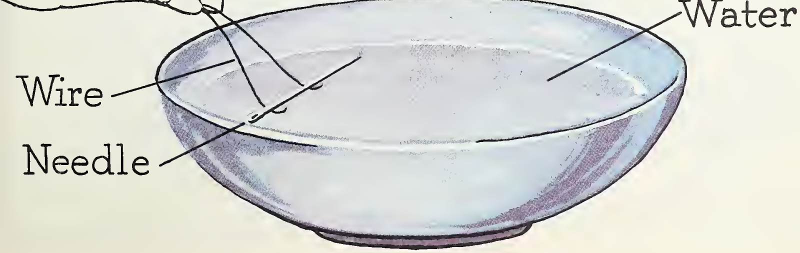
Water boatmen and backswimmers belong to the group of insects called "bugs." Bugs have sharp beaks instead of jaws. They suck up their food through their beaks. Water boatmen suck sap from water plants. Backswimmers catch small animals and suck out their juices.

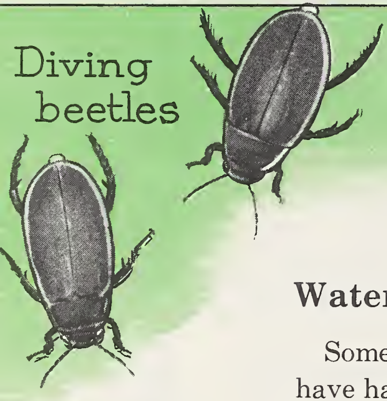
The water strider is another bug. You will usually see it on top of the water but it can dive beneath the water. It carries its air in a layer around its body when it is under water.

Some people call this insect a "water spider." Count its legs and you will see that it does not have as many legs as a spider has. Its body has a different shape, too.

A water strider does not float like a cork or swim like a frog. It walks around on top of the water.

An experiment will help you understand this. Lower a dry needle carefully to the water in a bowl. The needle will stay on top of the water. Many small things stay on top of the water this way.



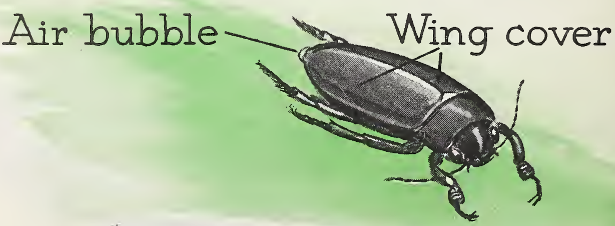


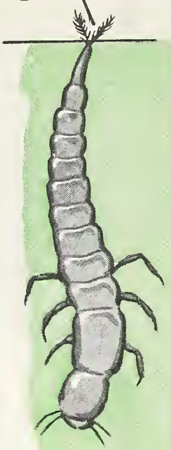
## Water Beetles

Some of the insects you catch may have hard wing covers over their wings. These insects are beetles.

Some of the water beetles are very good swimmers. They are shaped like little boats. They have strong legs shaped like oars. Watch them to see how they use these legs for swimming.

Water beetles like the ones on this page come to the top for air. They carry air under their wing covers and can stay under water for a long time. They change the air by pushing the back ends of their wing covers above the water.



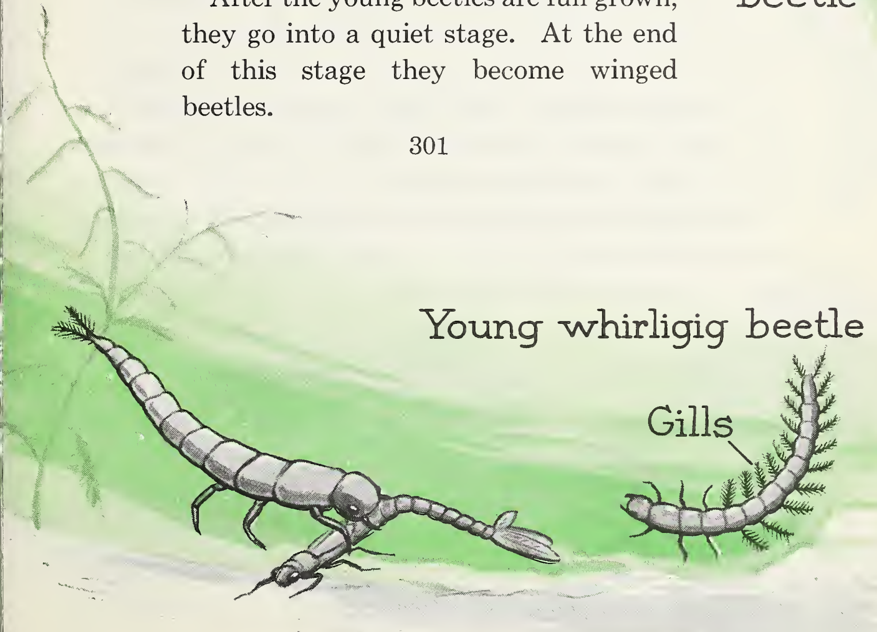


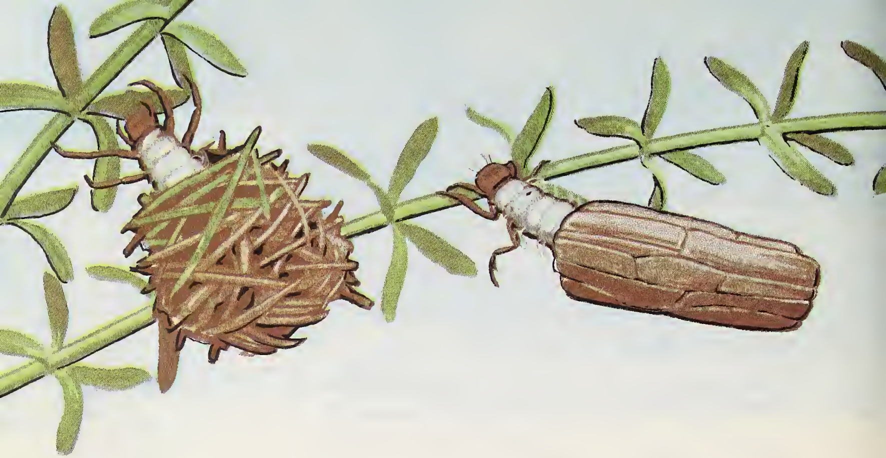
Young water beetles do not look like their parents. Name some other young insects that do not look like their parents.

Some kinds of young water beetles have gills. They can take their oxygen from the water. Other kinds have breathing tubes. They must go to the top of the water for air.

Young diving beetles feed on small animals such as insects, tadpoles, and small fish. Each young beetle has a pair of sharp, curved jaws which it drives into its food. The jaws are hollow and the young beetle sucks up the juices from the animals it has caught.

After the young beetles are full grown, they go into a quiet stage. At the end of this stage they become winged beetles.



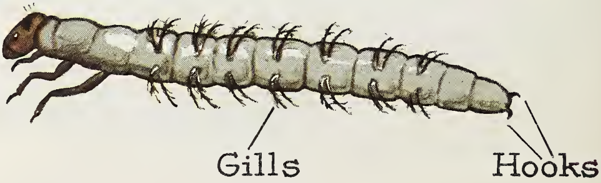


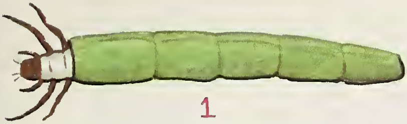
## Caddis Flies

You may find something that looks like a little bundle of sticks or a wad of tiny leaves. Watch it, and it may seem to come to life and crawl around.

Look at it closely and you will see that it is hollow. An insect lives inside. The insect can put out its head and legs to crawl around and feed. It can pull them back inside when there is danger.

This insect is the young of the caddis fly. It has gills and takes its oxygen from the water. It feeds upon tiny plants growing in the water.

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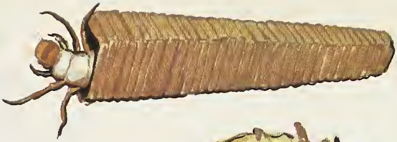
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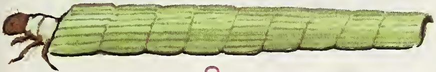
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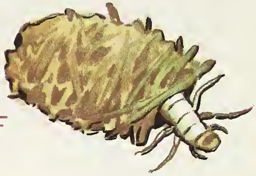
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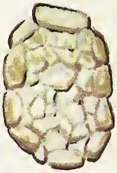
There are many kinds of caddis flies. Most of them make cases in which they live during their young stages.

Some caddis flies make cases of bits of leaves (1 and 2). Other caddis flies use tiny sticks (3 and 4). Young caddis flies that live in swift water often use little grains of sand (5, 6, and 7).

The young caddis flies spin a tough silk that they use to hold their cases together. As they grow, they may add new pieces to their cases or they may make new cases.

When the young caddis flies are full grown they spin a bit of silk across the fronts of the cases. Then they go into the quiet, pupa stage. At the end of this stage they come out as winged flies and leave the water.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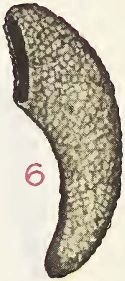
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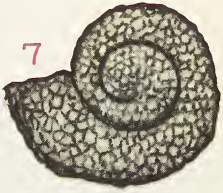
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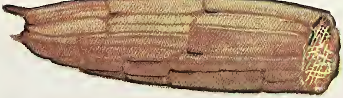
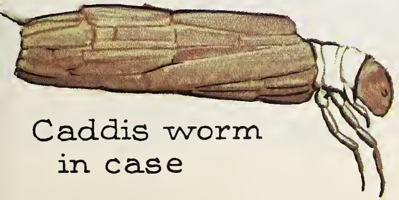
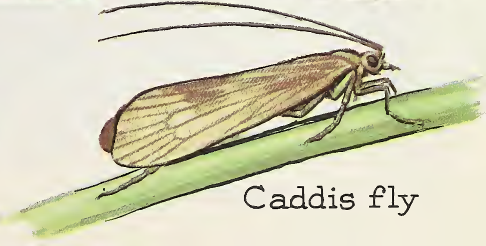
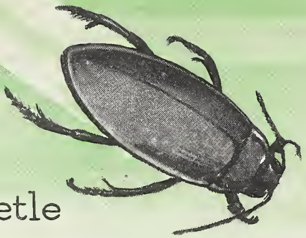
Egg


Pupa in case

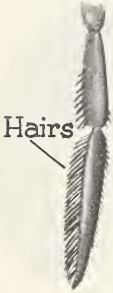

Caddis worm in case


Caddis fly



A streamlined beetle

Foot of a water boatman

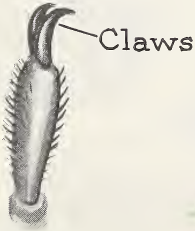


## How Water Insects Move About

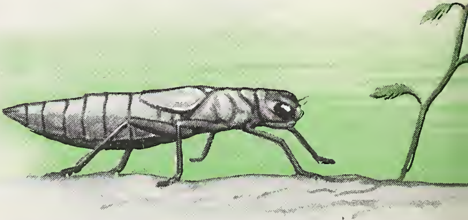
Full grown diving beetles and water bugs are very good swimmers. They have legs shaped like oars. Hairs on their feet act like the blades of oars.

These insects are shaped in such a way that they slip easily through the water. We say that they are streamlined. Can you name some other things that are streamlined?

Most water insects are able to crawl about on the bottom or among the water plants. They have strong legs and sharp claws. Look at the feet of water insects with a hand lens. Are there claws?



Foot of young dragonfly



Young dragonfly crawling

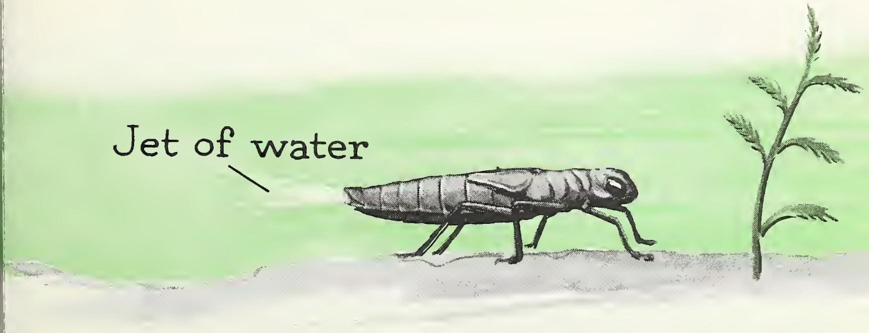
Young diving beetle wriggling through water

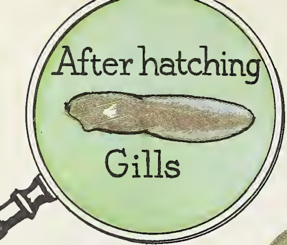
Several kinds of water insects swim by wriggling through the water. Did you catch any insects that swim this way? Watch them to see whether they use their legs to help them swim.

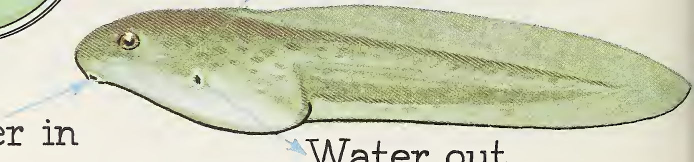
Young dragonflies have an interesting way of moving when they are frightened. Each dragonfly has an opening in the back end of its body. There are gills inside this opening. The young dragonfly gets oxygen by drawing water in through this opening.

If the young dragonfly is frightened, it may squirt water out through this opening. This makes it shoot forward like a jet airplane.

Put a young dragonfly in a pan of water. Touch it with a pencil point. It may squirt out water and shoot forward when you do this.







## Amphibians

Toads, frogs, and tree frogs are part of the group of animals that are called **amphibians.** They live the first part of their lives in water as tadpoles.

Tadpoles have gills and take their oxygen from the water. You can see the gills on a tadpole when it first comes from the egg, but soon a fold of skin grows over the gills. The picture shows how fresh water then gets to the gills.

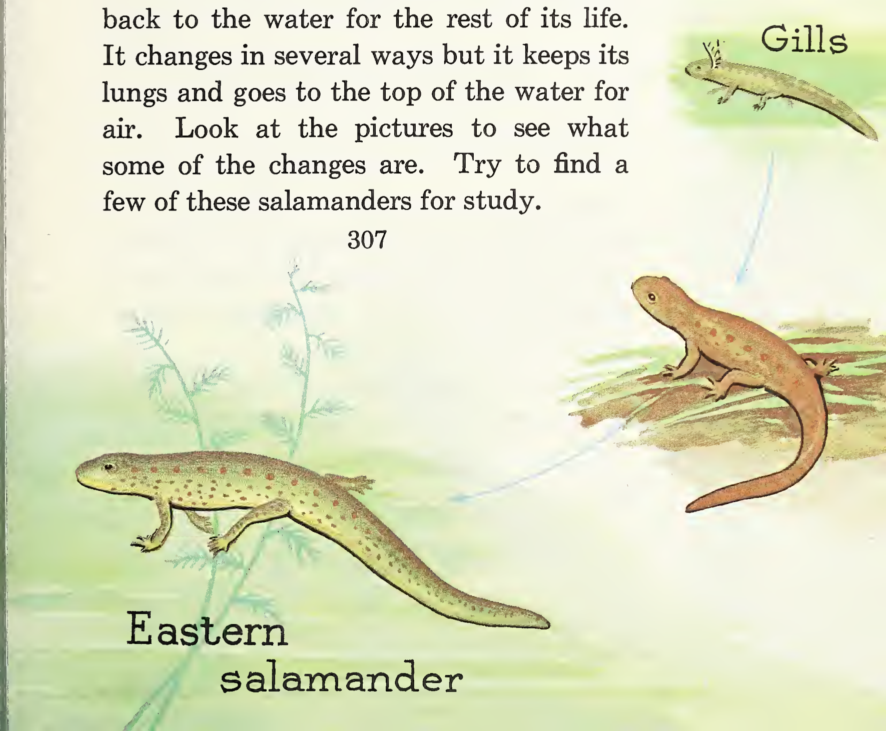
Later, the tadpoles lose their gills. They grow lungs and begin to take their oxygen from the air. How else do they change as they grow up?

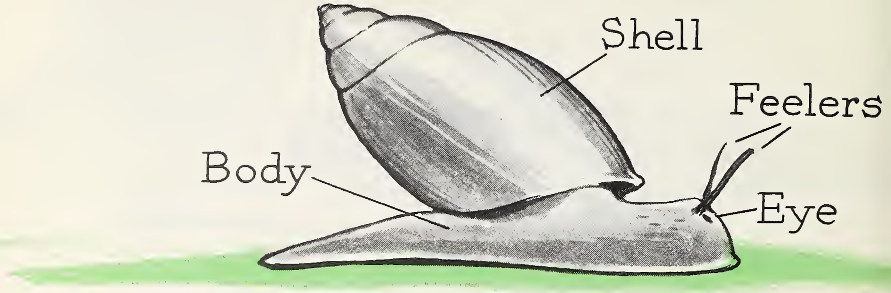
Salamanders are amphibians, too. Many people call them lizards, but lizards are reptiles. Salamanders have soft skins. Lizards have scales.

Most young salamanders have gills and live in water. A few kinds of salamanders keep their gills, but most of them lose their gills as they grow older. Some of them grow lungs and other kinds take in oxygen through their skin.

The eastern salamander has an interesting life story. It begins life in the water where it hatches from an egg. After a few months it loses its gills and grows lungs. Its colour changes at the same time. Then it goes on land and lives under rocks and logs.

After a year or so, this salamander goes back to the water for the rest of its life. It changes in several ways but it keeps its lungs and goes to the top of the water for air. Look at the pictures to see what some of the changes are. Try to find a few of these salamanders for study.



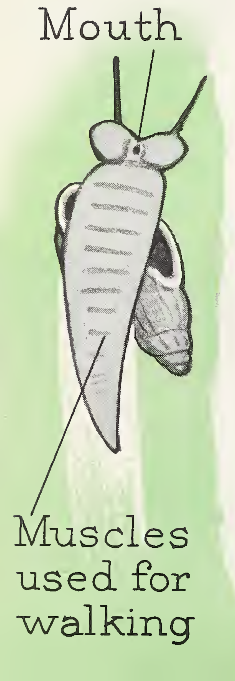


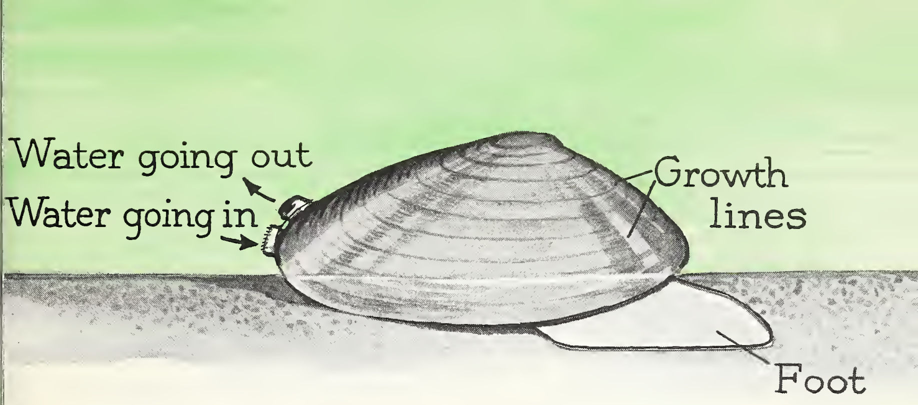
## Water Animals with Shells

Snails are common in ponds and streams. You will find them on plants or on bits of wood. They feed on the tiny plants that grow everywhere in quiet water. They also eat dead plants and animals.

The back of a snail's body gives off a chemical that becomes the shell. As the snail's body grows larger, the shell grows larger, too. The shell grows faster on one side than on the other, and this makes the shell curl around.

Snails have no legs. They crawl around by moving muscles on the bottom of their bodies. Watch a snail crawl up the side of an aquarium. You can see these muscles moving.

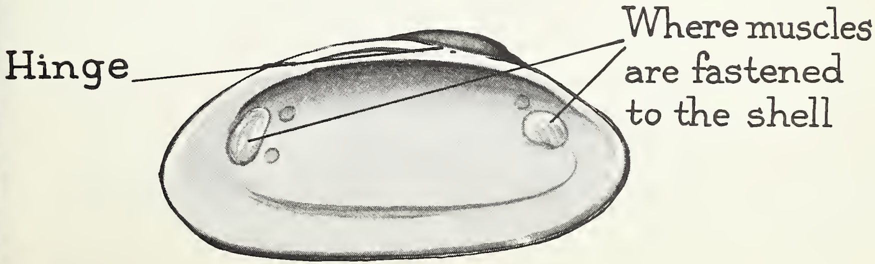


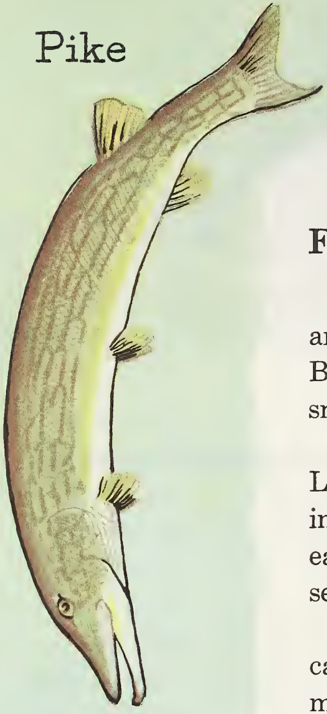


Clam shells are formed somewhat like snail shells. Part of a clam's body gives off a chemical that makes the shell. This chemical is given off by two sides of the clam's body so there are two shells instead of one. As the clam grows, the shells become larger at the edges.

A clam crawls by pushing out a part of its body called the "foot." The clam forces the foot into the sand or mud and then pulls up its body somewhat as an earthworm moves.

A clam sucks in water through a tube at the back of its body. Oxygen in the water goes into the clam's gills. Tiny plants and animals in the water are eaten by the clam. Then the water is forced out through another tube.



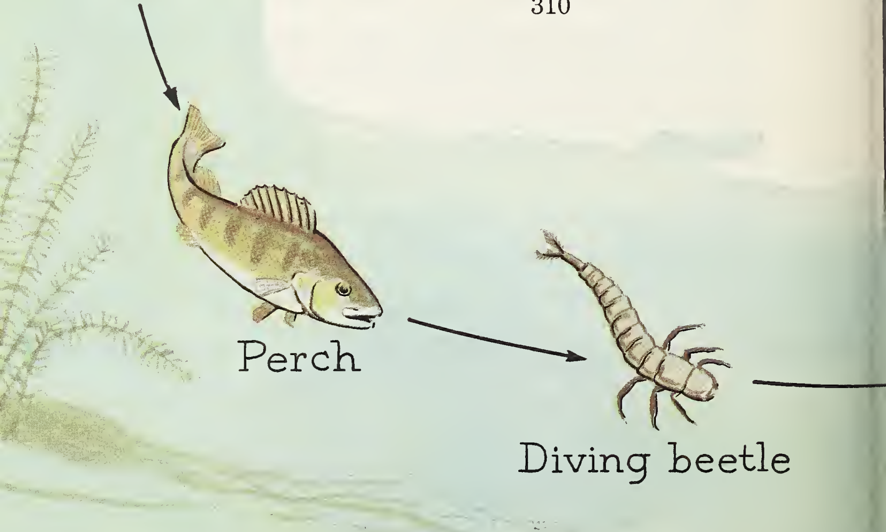


## Food Chains

In water, as well as on land, there are animals that eat other animals. Big fish eat smaller fish. The smaller fish eat tiny fish.

Some fish eat large water insects. Large water insects eat small water insects. Small water insects may eat animals so tiny that they can be seen only with a microscope.

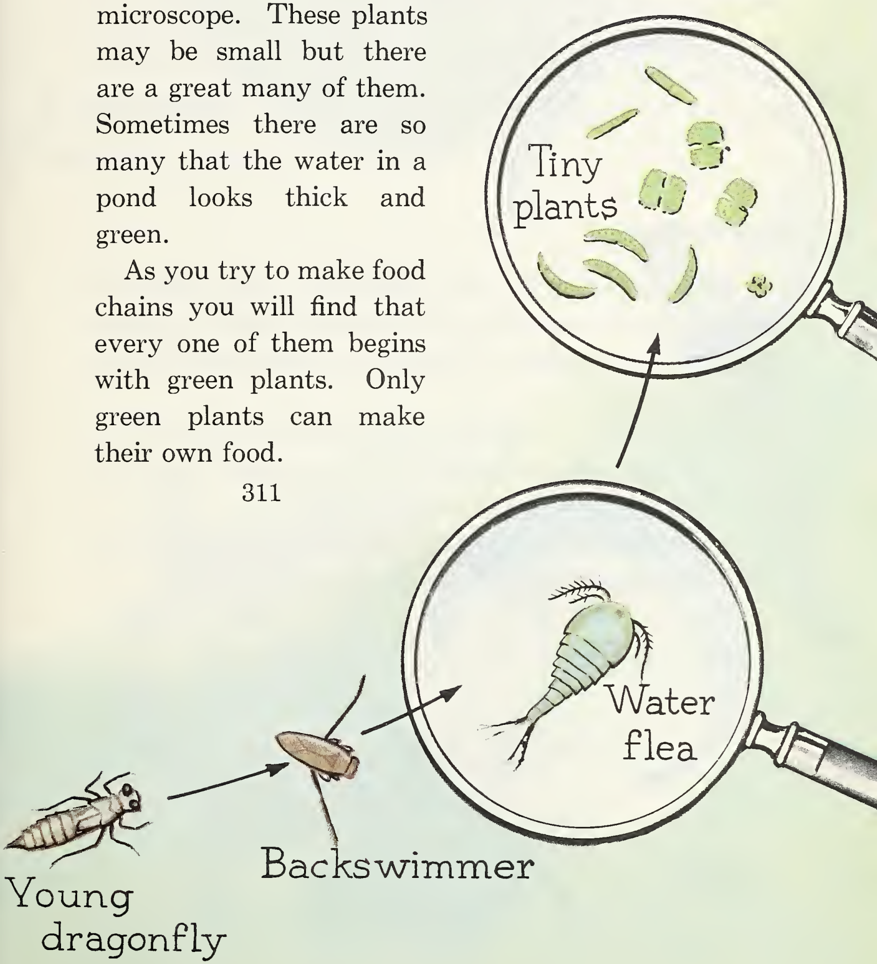
On these pages is drawn what is called a "food chain." Can you make up some other food chains?

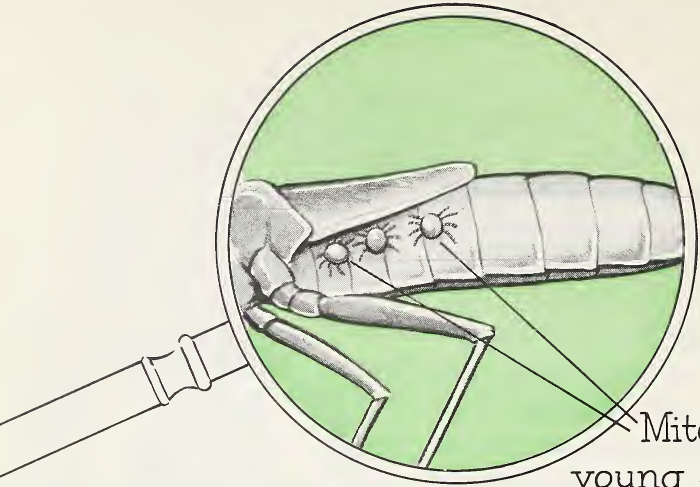


There is a beginning to every food chain. The beginning of the chain on these pages is the food of the tiny animals.

These animals feed upon green plants so small they can be seen only with a microscope. These plants may be small but there are a great many of them. Sometimes there are so many that the water in a pond looks thick and green.

As you try to make food chains you will find that every one of them begins with green plants. Only green plants can make their own food.





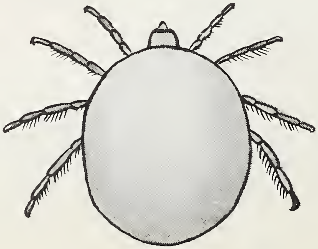
Mites on a young dragonfly

## Parasites

You may find some tiny animals on your water insects. With a hand lens you will see that they look something like spiders. These tiny animals are red and are called **mites.**

Many kinds of mites live on the bodies of larger animals. They suck out juices from the animals they live on. They are part of many food chains.

Small animals that get their food from larger animals are called **parasites.** These mites are parasites.

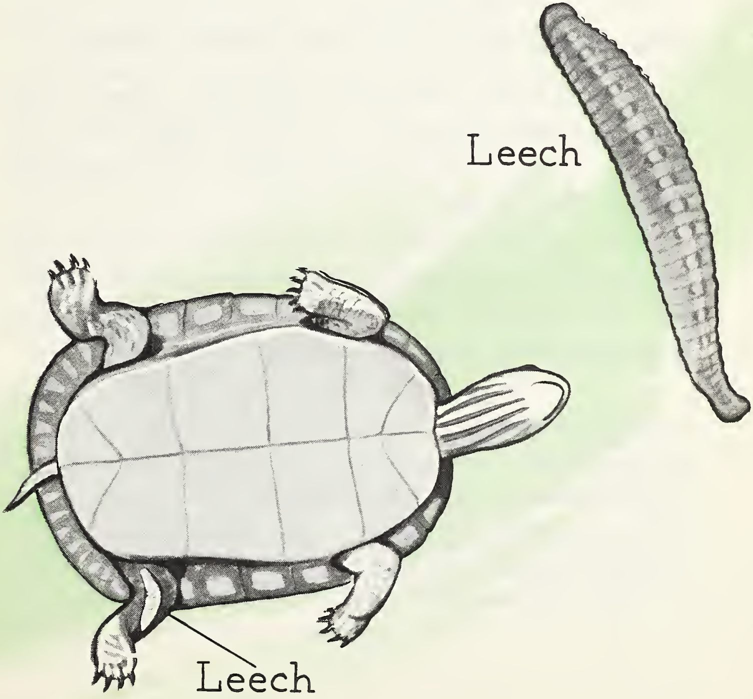


Mite

Sometimes you will find leeches on turtles. Leeches are often called "bloodsuckers."

Leeches fasten themselves to parts of an animal's body where they cannot be brushed off. Then they make small holes and suck out blood or other juices.

Some parasites, like mites and leeches, live on the outside of animals' bodies. There are many other parasites that live inside the bodies of animals. Some live in the stomachs and the intestines. Some live in the muscles. They often harm the animals they live in.



## The Real Beginning of a Food Chain

Animals cannot make their own food. They always feed on green plants or on other animals that eat plants. You will find green plants at the beginning of each food chain.

Green plants can make their own food. They use air and water and chemicals dissolved in water. They use the energy of sunlight. From these they make sugar and other foods they need.

---

1. What water insects live through four stages?
2. How does a young dragonfly catch its food?
3. How does a clam move from place to place?
4. How do water animals usually get oxygen?
5. What is at the beginning of all food chains?
6. What are parasites?

## The Major Topics Presented in Each Unit

**Unit 1 — Insects That Work Together.** Life histories of some social insects. How their colonies are organized. How different living things may depend upon each other.

* **Unit 2 — Controlling Fires.** What is needed for fires to burn. How fires can be put out. Some precautions with fire.

**Unit 3 — Streams at Work.** How streams wear away the land. What happens to material that is worn away. How some common rocks and fossils are formed.

* **Unit 4 — Sugar and Starch.** Where starch and sugar may be found. Why starch and sugar are important to plants and animals. How starch is changed to sugar in our bodies.

* **Unit 5 — Warm Weather Indoors.** How water and air behave when heated. Some ways our homes are heated. Why moisture in the air is important.

**Unit 6 — Animal Tracks and Signs.** Some ways we can tell where animals have been. Some problems of our common animals. Some habits of our common animals.

**Unit 7 — The Winter Sky.** How to find some common constellations. Some other heavenly bodies in the winter sky. The observable motions of the heavenly bodies.

* **Unit 8 — Electric Circuits.** The nature of an electric circuit. Providing and using electrical energy. Safety precautions in the use of electricity.

***Unit 9—Rainbow Colours.** Separating the colours in sunlight. Why we see different colours in some common things. How we use some of the invisible colours in sunlight.

**Unit 10 — Plants and Light.** How green plants are affected by light. How green plants use sunlight in making food. What happens to some of the food green plants make.

**Unit 11 — Lifting Things.** Some simple machines and complex machines for lifting things. How complex machines are usually made of two or more simple machines.

* **Unit 12 — Boats.** Why things float and sink. Some safety precautions with boats. How boats are moved and steered.

**Unit 13 — Flowers and Their Work.** The important parts of some common flowers. How seeds develop in plants. How pollen is distributed from flower to flower.

**Unit 14 — Life in Quiet Water.** Some common animals that live in quiet water. How common water animals get food and oxygen. How all animal life depends upon plant life.

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* These units include health and safety material.

# Index

air, 23, 31, 40–43, 93–98, 102–103, 110–112, 246, 296–309, 314
almanac, 151
amphibians, 306–307
animals, 4–24, 66–70, 82, 92, 113–136, 190–191, 211, 271, 278–279, 284–285, 291–314
ants, 4–15
aphids, 13
apples, 76, 81, 84, 271–274
aquarium, 221, 293
automobile, 161, 176, 246

backswimmers, 298
bacteria, 78
bait, 124
bark, 121, 131, 135
beans, 277
beaver, 134–135
bees, 18–24, 271, 278–279
beeswax, 19, 23
beets, 85
  sugar, 73
bellows, 42
berry bushes, 121
Big Dipper, The, 137–141, 144–146
birds, 190
biscuits, 72
blackberries, 76
blood, 82, 86, 89
blower, 97
boiler, 100–101, 104, 175
bones, 66–67
brace, 241
bread, 81, 72
breathe, 91, 296, 306, 307
buds, 272–273
buoyant force, 247–263
burrow, 114
butterflies, 7, 190, 284–285
cabbage butterfly, 190
caddis flies, 302–303
cake, 72
campfires, 32, 35, 39, 48
candles, 27–32, 40–41
cane sugar, 73
carrot, 85, 204
casts, 66–69, 116–119
Cassiopeia, 137, 140–141, 144–146
cat, 115, 117
caterpillars, 190
cattails, 220
celery, 204
cellophane, 192–193
cement, 62–65
charcoal, 33
cherries, 76, 78–79
chimney, 43, 97
Christmas-tree lights, 168
cigarette lighter, 41
circuits, electric, 157–180
clams, 68–69, 309
clam shells, 68–69, 132, 187, 309
claws, 115, 304
clay, 65
coal, 106, 227, 232, 233
cocoon, 7, 8, 17, 21
colonies, insect, 4–24
colour, 29-32, 179—198, 278
comb, insect, 17, 19–21
concrete, 62–63
conductor, electrical, 160–161
cones, pine, 123
conglomerate, 64–65
constellations, 137–147
convection, 94–104
cookies, 72
corn, 76, 92, 211, 217, 288–289
  starch, 80–81, 87
  syrup, 74
cottonwood, 283
cows, 131

crackers, 86
crank, 225, 243

dam, 134, 174
damsel fly, 297
dandelion, 213
day, 148–149
deer, 130–131
deermice, 126
delta, 60–61
derrick, 223, 238–240, 242–243
dessert, 75
Diesel engine, 177
dinosaurs, 67
digestion, 12, 86–89
diseases, 125
dissolves, 82–91, 278, 297
diving beetle, 300–301, 304–305
dog, 113, 115, 116
dragonflies, 294–295, 304, 305
drone, 18, 21
dust, 194–195

Eagle, The, 147
earth, 145, 148–154, 195
eel grass, 220
egg, 7, 8, 11, 19, 20, 21, 295, 306
electrical bell, 173
  generator, 174–177
  heater, 98, 106, 197
electricity, 155–178
electric lamp, 95, 99, 155–172, 174, 176, 197
    lamp cord, 47, 158–159
    motor, 177, 227, 229
elevators, 228–233
energy, 26–48, 52–57, 90–92, 94–112, 148–149, 161, 174–178, 199–222, 268–269, 314
erosion, 49–70
evaporation, 23, 28–29, 38, 73, 77, 107, 110–111
evening primrose, 285
Evening Star, 150–151
exit, 45

fat, 92
feathers, 191
female, 11, 16, 18, 282–283, 286, 288
fern, 218
filter, 51, 83
fire, 25–48, 90, 94, 96, 106–107
firemen, 44
fireplace, 32, 42, 46, 48
fire prevention, 39, 46–48, 171
fish, 66, 301, 310–311
flame, 25–48, 90
flashlight, 141
flies, 7
flowers, 22–23, 271–290
food, 71–92
  chains, 310–314
footprints, 67, 113–134
forces, 223–246, 247–263
fossils, 66–69
freckles, 198
fresh water, 262–263
friction, 36, 37
frogs, 191, 296, 306
fruit, 17, 76–79, 274–290
fuel, 91, 106–107
furnace, 94–97
fuse, 171

gardens, 216–217
gases, 28–30, 32–34, 107
gasoline, 47, 176, 227
gelatine, 75
generator, 174–177
gills, 297, 306–307, 309
glaciers, 70
gland, 24, 86
glass, 196
globe, 145
grain, 125, 232, 233
grass, 6, 126, 127, 206, 213, 287
gravel, 63
green colour in plants, 204–222
greenhouse, 196
ground, 6
grub, 7, 8, 17, 21

hair, 191

Harp, The, 147
hay fork, 235
  loader, 232
heat, 25–48, 90–91, 93–112, 148, 159, 171
heater, 94–107
hive, 4–5, 18–19, 22, 271
honey, 9, 21, 22, 23, 74, 278
honeycomb, 19
honeydew, 13
house plants, 219
houses, for animals, 114, 123, 126, 127, 132, 135
  for people, 93–112, 125, 155, 167
human body, 86, 88–89, 91, 110–111, 198

ice, 70
Indian pipe, 220
Indians, 37, 114
infra-red light, 196–197
insects, 4–24, 190, 271, 278–279, 284–285, 294–305, 310–312
insulation, electrical, 160
  heat, 108–109
intestines, 88–89
invisible light, 196–198
iodine, 80–81, 83–84, 207
ivy, 203

jam, 78–79
jaws, 10, 301
jet, 305
Jupiter, 151

lake, 58, 174
lawn, 128, 213, 218
leaves, 199–220
leeches, 313
lemon, 75
lever, 264
life preserver, 266
light, 148–153, 155–170, 172, 176, 179–222, 314
limestone, 65
Little Dipper, The, 137–141, 144–146
loader, 232
locomotive, 177
lungs, 91, 306

male, 11, 16, 18, 282–283, 286, 288
maple sugar, 73
Mars, 151
mating flight, 11, 18
match, 26, 28, 32–37, 46
meadow mice, 121, 127
melting, 26, 28–29, 161
metal, 160–161, 170–171
meteors, 154
mice, 125–127, 129
mines, coal, 227
mites, 312
moisture, 110–111
molasses, 73
mole, 128–129
moon, 143, 152–153
Morning Star, 150–151
mosquitoes, 296
moss, 218
moth, 284–285
motor, 226–227
motorboat, 268–270
mould, 79
mouth, 86, 88–89
mud, 59, 68–69
mullein, 213
muscles, 82, 90–91
mushrooms, 15, 222
muskrat, 114, 117, 118, 132–133

nasturtium, 278
nectar, 22–23, 278, 284–285
nests, 4–5, 16, 123, 126, 127
North Star, 137, 139–141, 144–146
nut, 123

oak, 286
oars, 264–265, 298, 300
oats, 200
ocean, 58, 68–69
oil, 107, 177, 186, 211, 246
opals, 187

orange, 75, 76
Orion, 142–143, 147
ovule, 277, 280–281, 288–289
oxygen, 40–43, 44, 90–91, 296–309

paper, 16
parasites, 312–313
parsnips, 85
peanuts, 211
pearls, 187
pears, 76
peas, 76, 275, 277, 281
pickles, 72
pie, 72
pistils, 276–288
planets, 150–151
plantain, 213
plants, 12–13, 15, 22–23, 66, 73, 76–77, 78–79, 81–82, 84–85, 199–222, 271–290, 292–293, 298, 309–311, 314
  water, 220–221, 298, 309–311, 314
plaster, 116–119
Pointers, The, 139
poison, 24
pond, 132–135, 220–221, 291–314
pondweed, 220
pollen, 21–23, 276–290
potatoes, 81, 201, 210, 216
prism, 181, 184–185
propellers, 268–270
prunes, 77
pudding, 72
pulleys, 234–239
pump, 100
pumpkin, 275, 282
pupa, 7, 17, 21, 303
push-button switch, 173
pussy willow, 283

queen ant, 8, 11
queen bee, 18, 20, 21
queen wasp, 16
question board, 162–165

rabbit, 113–114, 118, 120–121, 122, 127, 131, 190
raccoon, 117–118
radiant heating, 105
radiator, 100–105
radish, 205
rainbow, 180–187
raisins, 77
rats, 125, 133
red squirrel, 123
reflection, 151, 153, 180, 188–191, 196
river, 68–69
rock, 49–70, 154
rowboat, 264–267
rubbish, 47, 136
rudder, 270
runways, 114

safety, 39, 44–48, 161, 171, 178, 198, 266–267
salamander, 307
saliva, 86–89
salt water, 262–263
sand, 59, 62, 64, 233
sandstone, 64
sap, 298
Saturn, 151
Scorpion, The, 147
seasons, 149
sediments, 50–51, 58–61, 64–69
seeds, 15, 211, 217, 274–275, 277, 280–281, 285, 288–289
Seven Sisters, The, 147
shale, 65
shells, 65, 66, 68–69, 308–309
ships, 226, 239, 247, 252–253, 263, 268
short circuit, 170–171
shrew, 128–129
skunk, 118
sky, 137–154, 194–195
slaves, 15
smoke, 95, 97, 99
snails, 66, 308
snow, 120, 123–124, 126–127, 130

soap bubbles, 187
soil, 7, 50–69, 128–129, 232, 244–245
spark plugs, 176
sparrows, 190
sphinx moth, 285
squash, 290
squirrel, 122–123
stamens, 271–288
starch, 71, 80–92, 207–211
stars, 137–154
steam, 104, 175, 227
sting, bee, 24
stoker, 106
stomach, 12, 22, 88–89
stone, 6, 49–70
storage battery, 176
stove, 94
strawberries, 76, 275
streamlining, 304
streams, 49–70
submarine, 258–259
  diver, 260–261
sugar, 9, 71–79, 82–92, 209–211, 278
summer, 146–147, 149

tadpoles, 301, 306
tan, 198
taste, 74–77, 86
teasel, 213
teeth, 121, 131
temperature, 102–103, 108–112, 196–197
thermometer, 93, 102–103, 108–109, 110–112, 196
thermostat, 112
time, 148
toads, 191, 306
tongue, 74, 284–285
towers, 240
tracks, 67, 113–134
trees, 121–123, 126, 131, 134–135, 202, 212–215, 271–274, 283, 286
triangles, 240–241
tulip, 276–277
tunnel, 6, 9, 13–15, 123, 128–129, 133
turbine, 174–175
turnip, 85
turtle, 296, 313
twigs, 121, 131

ultra-violet light, 198
umbrella, 145

valley, 55–57
vegetables, 275
Venus, 150–151
vines, 202
vitamin D, 198
voltage, 178

walnuts, 211
wasp, 16–17
water, 38–39, 48–69, 73–78, 80–89, 100–104, 110–111, 114, 117, 132–135, 174–175, 179–180, 182–183, 186, 194, 220–221, 247–270, 291–314
  beetle, 300–301
  boatman, 298
waterfall, 53–54, 183
water scorpion, 296
  strider, 299
weasels, 191
weeds, 213, 217
weighing, 250–251
wheat, 81, 211
whirligig beetle, 300–301
wick, 26–27
wind, 42–43, 286–289
windlass, 224–231, 238, 243
wings, 11, 23, 295, 300
winter, 113–136, 137–156
wire, 156–173, 178
wood, 14, 16, 32–39
woods, 212, 215, 218
workers, 11, 16–24

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